NISTIR 4985

A User's Guide for CFAST Version 1.6

Rebecca W. Portier
Paul A. Reneke
Walter W. Jones
Richard D. Peacock

Building and Fire Research Laboratory
Gaithersburg, Maryland 20899

.NIST

United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

A User's Guide for CFAST Version 1.6

Rebecca W. Portier
Paul A. Reneke
Walter W. Jones
Richard D. Peacock

December 1992

Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

CONTENTS

User's Guide for CFAST Version 1.6

Rebecca W. Portier
Paul A. Reneke
Walter W. Jones
Richard D. Peacock

Building and Fire Research Laboratory
National Institute of Standards and Technology

CFAST is a zone model capable of predicting the environment in a multi-compartment structure subjected to a fire. This guide provides a detailed description of the pre- and post-processing routines used by the model, the data input requirements, and the output produced by version 1.6 of the model.

Key words: compartment fires; room fires; fire growth; mathematical models; numerical models; smoke; toxicity

1. INTRODUCTION

Considerable research has been done regarding the spread of fire and smoke from a compartment of fire origin to connected compartments. The work is motivated by a need to understand and predict the environmental conditions which occur as a fire develops and spreads. Much of the attention has focused on the development of numerical models which are able to make a reasonably accurate assessment of the environment resulting from a specified fire. CFAST [1][1] is such a model. This reference guide covers the use of the computer programs which comprise CFAST.

CFAST is a model which is intended to predict fire growth and smoke transport in multi-compartment structures. This model is the result of a merger of ideas that came out of the FAST [1,2] and CCFM.VENTS [3] development projects. The implementation consists of a set of programs to describe the structure to be modeled, run the model and produce usable output. This guide provides detailed instructions for operating each of these programs and a description of the data input file requirements. A companion technical reference guide [4] and several additional papers [5,6,7,8] provide details of the physical basis of zone models, the development of the predictive equations, the limitations of the current implementation of the model, and the level of agreement with experimental measurements.

---

[1] Numbers in brackets refer to literature references listed in section 8 at the end of this report.

Functionality within CFAST is provided by the following programs:

CEdit	interactive input
CFAST	the model itself
CPlot	interactive output to display data produced by the model
Report	produce time history (ASCII) output text
ReportG	animation of graphics description(s)

CFAST and most of the associated routines work on a wide variety of hardware, from supercomputers through microcomputers. CEdit is specific to MS DOS[2] based microcomputers, although it does generate an ASCII data file which can be used with CFAST on other computers. There are also several utility routines discussed later.

The order for the remaining sections of this guide represents a typical progression in using the CFAST model. These sections should be reviewed sequentially by those unfamiliar with CFAST and its associated routines. The presentation for each section assumes the use of MS DOS microcomputers. Alternate command lines are detailed in Appendix B. Section 2 details the contents of the diskettes distributed with CFAST 1.6 and the installation instructions for the software. Section 3 covers the interactive input editor, CEdit, which can be used to specify the physical phenomena and structural geometry of a fire scenario. Section 4 describes the operation of the CFAST model and provides some sample output. Section 5 demonstrates the use of output from the model in generating a variety of graphical presentations within CPlot. Section 7 discusses a variety of utility routines available in CFAST including Report and ReportG.

Throughout the remaining sections of this guide an example data input file, "PRM.DAT", is referenced. Each line of this file details some aspect of the fire scenario by specifying one of a limited number of recognized phrases or key words at the beginning of each line. A complete listing of this file can be found in Appendix A. This example file is not intended to illustrate all available CFAST input key words. Additional examples can be found in the appendix with "PRM.DAT" as well as in the Fire Hazard Assessment Methodology [9]. Additional data files are also supplied with the model as a means of testing the various components. A complete list of key words available in CFAST is provided in Section 6 for those who prefer to edit the input file using an ASCII text editor.

---

[2] The use of company names or trade names within this report is made only for the purpose of identifying those computer hardware or software products with which the compatibility of the programs of CFAST has been tested. Such use does not constitute any endorsement of those products by the National Institute of Standards and Technology.

2. DISTRIBUTION AND INSTALLATION

2.1 New in CFAST 1.6

- New horizontal flow (doors) and vertical flow (ceilings) algorithms

- New conduction and radiation algorithms

- Ceiling jet algorithm

- Multiple fire objects

- Generates better solutions since the pressure equations are more accurately calculated

- CFAST input files allow up to 15 compartments, 18 ducts, and 5 fans

- Press the <f5> function key within the CFAST model to show the current time and time step. Press escape to stop the model.

- Faster calculations. By way of comparison, the actual clock time required to get to the first second of simulation time and a subsequent simulation time of 1200 seconds with one of our test cases is:

CFAST Version	After 1 Second Simulation	At 1200 Seconds Simulation	Elapsed Time
1.4	0.4 s	127.7 s	≈ 127 s
1.5	12.2 s	41.6 s	≈ 29 s
1.6	1.9 s	21.5 s	≈ 20 s

2.2 Hardware Requirements

- A 386 or higher PC with at least 2.5 megabytes of free extended memory, or a Unix platform. CFAST does not run on 8086 microcomputers.

- A graphics display included on the list of supported displays in Appendix E

NOTE: CFAST on a PC looks first for expanded memory, then XMS memory, then unmapped EMS memory. It utilizes the first type that is available and cannot mix types. Thus, if there is expanded memory available, but not enough, the error message "insufficient memory to load EXP file" is displayed. The intention is to reduce memory requirements in later versions.

2.3 Contents of the Distribution Disks

CFAST routines:

File Name	Function
CEdit	The data editor. Use CEdit when creating or modifying the ASCII input file. Previous versions of CFAST provided the <f4> function to run the model within CEdit. This functionality is no longer supported.
CFAST	This is the model.
CPlot	Produce plots, lists, *etc*.
Report	The report generator (reproduce original listings).
ReportG	A routine to replay the graphics output as though the CFAST model were being run without actually running the model. Functions like a VCR.
CF_Set	Modify the configuration file HV1.CF.
List_clr	Show the colors that will be used by the main model.
List_tpp	List the thermophysical database.
List_obj	List the data in the multiple objects database.
Obj2df	Converts OBJECTS.ORG to OBJECTS.DF. Allows the user to edit OBJECTS.ORG and then generate an OBJECTS.DF file in the proper format.

ASCII data files required by CFAST:

File Name	Function
HV1.CF	User-specific configuration information such as the path to search for data input files, color settings within CEdit, and the default units.
CPLOT.CF	Configuration file for CPlot.
HLPTXT.CV1	Required to provide context-sensitive help information within CEdit.
THERMAL.DF	Details the thermophysical properties for several preselected materials. This database file is discussed in detail in Appendix C for users who need to modify the current contents.
OBJECTS.DF	Contains the burning characteristics and geometric details of a limited number of common objects such as a table or chair. This database file is discussed in detail in Appendix D for users who need to modify the current contents. This file should never be edited by the user.
OBJECTS.ORG	Contains the same details as OBJECTS.DF. This file can be modified by the user. Once modifications are completed, OBJ2DF.EXE can be used to generate the proper OBJECTS.DF file. See Appendix D for details.

Data input files to be used in testing for proper installation of the software:

File Name	Function Tested
TEST01.DAT	Initialization
TEST02.DAT	Multiple compartments
TEST03.DAT	Multiple compartments
TEST04.DAT	History File
TESTG1.DAT	Basic Graphics
TESTG2.DAT	More Basic Graphics
TESTG3.DAT	3D Views
TESTOBJ1.DAT	Multiple Fires

Building descriptor files required to produce CFAST graphics for the TESTG3.DAT data file:

File Name	Description
TESTG3T.PIC	Cross-sectional view
TESTG3B.PIC	Plan view

Graphics files required by the kernel. One file for each extension is needed:

File Name	Function
*.DSP	Device dependent graphics instructions.
*.FNT	Fonts.
DEVFONT.*	Fonts.
*.KRN	Graphics kernel.
*.LOC	Device locator interface to kernel.

2.4 Installation

An automatic installation program which prompts you for the necessary information and copies the CFAST files onto your hard disk is included on the distribution disks for CFAST. Since the CFAST programs are provided on the diskettes in compressed form (to save disk space), you must use the automatic installation program to copy CFAST to your hard disk. For those in need of specific custom installations for unique hardware, several utility programs are provided to customize CFAST for your system.

To install CFAST on your PC computer system, place the diskette labeled "**CFAST Disk #1**" into diskette drive A: and enter the following DOS commands:

```
A:
INSTALL
```

Several questions are asked about the computer system and how and where to install the modules. You may answer none, some, or all of the questions as appropriate for your specific needs. Follow the directions on the screen closely and provide answers to questions as desired. Usually, the defaults provided by the installation program are sufficient. On several of the screens, you are asked to fill in information or change the defaults suggested by the installation module if desired. These screens are described in more detail below.

```
On which disk drive do you wish to install CFAST?

                              Drive A:
                              Drive B:
                              Drive C:
                              Drive D:
                              Drive E:
```

CFAST is installed in a single subdirectory on a hard disk. The first two screens prompt for the drive letter of the hard disk (usually C:), and the name of the target directory. For most installations, the defaults are sufficient provided the drive selected contains at least four megabytes of free space. For custom installations, any drive containing at least four megabytes of free space may be selected. Any valid nonexistent directory may be used for the program directory. Once installed, additional directories can be set up for datafiles, databases and so on.

As the files are copied from the installation diskettes to the hard disk, the installation program shows the progress on the screen. Prompts are displayed at the appropriate times prior to inserting each of the distribution disks.

```
        Writing: C:\CFAST16\CF_SET.EXE
        Reading: Library File --> LIST_CLR.EXE
      Verifying: LIST_CLR.EXE
  Decompressing: C:\CFAST16\CF_SET.EXE
        Writing: C:\CFAST16\LIST_CLR.EXE
        Reading: Library File --> CPLOT.EXE
      Verifying: CPLOT.EXE
  Decompressing: C:\CFAST16\LIST_CLR.EXE
        Writing: C:\CFAST16\CPLOT.EXE
        Reading: Library File --> REPORT.EXE
      Verifying: REPORT.EXE
  Decompressing: C:\CFAST16\CPLOT.EXE
        W┌─────────────── PRESS ANY KEY ──────────────┐
        R│ Please place the Master Distribution Disk labeled │
      Ver│ "Disk #2" version: 1.6 Beta Test in drive A:       │
  Decompr│ Press the [Esc] key to abort, any other key to continue... │
        W└──────────────────────────────────────────────┘
        Reading: Library File --> CFAST.EXE
      Verifying: CFAST.EXE
  Decompressing: C:\CFAST16\CEDIT.EXE
        Writing: C:\CFAST16\CFAST.EXE
  Decompressing: C:\CFAST16\CFAST.EXE
```

In order to operate correctly, the installation module may need to create or modify the FILES= statement in the DOS startup file CONFIG.SYS. If you wish to modify the file

yourself, you may skip this step. The FILES= statement must specify a minimum of 20 files for the software to operate correctly.

2.5 Test Cases

Eight data input files are provided as test cases. They are intended only to test various capabilities of the computer and ascertain whether the model is working. The following table lists the files along with the purpose of each and sample execution times obtained using a 486 PC.

File Name	Simulation Time (s)	No. Rooms	Execution time (s) on a 486/25 (s)	Function Tested
TEST01.DAT	10	1	2	Initialization
TEST02.DAT	10	6	54	Multiple compartments
TEST03.DAT	10	6	23	" "
TEST04.DAT	300	6	360	History File
TESTG1.DAT	35	1	23	Basic Graphics
TESTG2.DAT	35	1	15	More Basic Graphics
TESTG3.DAT	300	6	294	3D Views
TESTOBJ1.DAT	300	2	17	Multiple Fires

To test the installation and computer performance, run each of the test cases in turn. The command for TEST01.DAT is:

```
CFAST TEST01.DAT
```

3. CEdit

CEdit is an interactive, user-friendly program used to generate most data files for input to the CFAST model. As such, it is difficult to describe all the functions of the program in a reference guide. Rather, it is best learned through use. This section will describe the types of information entered on each of the screens of CEdit and relate those to the specific sections of Section 6 which describe the corresponding CFAST input file key words.

3.1 Using CEdit

The user interface is organized into a series of screens, each of which addresses a general area of the process of modeling a fire. General and key word help is always available except within the key word help section itself. The top of the screen shows which section is active. These names are shown below and are roughly descriptive of the area which is covered. The bottom of each screen shows which special keys are active, or indicates what action is expected. If data can be entered, then the range and units are shown if appropriate. For example, compartment width is in units of length, whereas a title has no dimensions.

0	Initialization	only at the beginning
1	Overview	
2	Ambient Conditions	
3	Geometry	
4	Vents (doors,...)	
5	Vents (ceiling,...)	primary sections
6	Fans, Ducts,...	
7	Thermal Properties	
8	Fire Specification	
9	Objects	
10	Files,...	
11	Version and Settings	show the current CFAST version number and make permanent changes in the colors and units

Note that the Initialization screen (screen 0) and the Version and Settings screen (screen 11) do not correspond to sections of the data file. Rather, they are used to retrieve a CEdit data file and to customize the CEdit display environment, respectively.

Overview	Title from section 6.2.1 Time specifications from section 6.2.1
Ambient Conditions	Ambient conditions from section 6.2.2
Geometry	Floor plan data from section 6.2.3
Vents(doors,...)	Horizontal flow connections from section 6.2.4
Vents(ceiling,...)	Vertical flow connections from section 6.2.5
Fans, Ducts,...	Mechanical ventilation from section 6.2.6
Thermal Properties	Thermophysical properties of enclosing surfaces from section 6.2.7
Fire Specification	Description of fire sources from section 6.2.8 Species production from section 6.2.8
Objects	Object specifications from section 6.2.9
Files,...	File specifications from section 6.2.10

In general, CEdit requests either data from the keyboard, or selection information from the function keys (or mouse if present). Any active function keys are shown at the bottom of the screen. If the meaning is not clear, the **show keys** function key, f9, will give further explanation. Otherwise, there are directions as to what further actions are possible. Select an entry to be changed by moving the highlight bar using the arrow keys (← ↑ ↓ →). If alphanumeric input (data) is being requested, the entry must always be completed by pressing the Enter key. For function keys, only a single keystroke is required. Some of the function keys are active throughout CEdit; others are specific to certain screens. Those specific to individual screens are described in more detail on the following pages. Those active throughout the program are discussed below.

key	key label	function
f1	help	You may press the HELP key, f1, at any time to receive context sensitive help describing the current screen or current quantity being entered. Pressing f1 a second time brings up a list of key words for which more detailed help is available.
f2	go to screen	Allows you to move directly from one screen to another within CEdit. From any screen, pressing f2 brings up a menu listing all the screens in CEdit. Using the mouse or the arrow keys, select the screen of interest and press enter or the left mouse button.

f8	change units	You may temporarily change the working engineering units displayed by CEdit and used for data entry at any time by pressing f8 and selecting the quantity to be changed with the up and down arrow keys. Pressing the right or left arrow keys changes the working units of the currently selected quantity. To change the units permanently, you must modify the installation parameters.
f9	show keys	Provides a brief description of the function keys currently active and can be used to provide a quick reference of the current function of each of the keys.
f10	quit	Used to end CEdit.

Four additional keys have special meaning in CEdit when pressed on any of the main screens (screens 1-11 above).

key	key label	function
Home	first screen	Move immediately to the Overview screen from any CEdit main screen.
End	last screen	Move directly to the Files screen from any CEdit main screen and save the current changes.
PgDn	Page Down	Move one screen forward. Forward direction is determined by the order of the screens on the **go to screen** (f2) menu.
PgUp	Page Up	Move one screen backward. Backward direction is determined by the order of the screen on the **go to screen** (f2) menu.

Again, these special keys must be used from one of the main screens to retain their functionality. Alternate meanings exist within many of the subpages or windows displayed by each screen. When an alternate meaning does apply, this is indicated in the sections below.

There are several ways to start CEdit. The simplest is to enter the command:

cedit

Refer to Appendix B for alternative CEdit command lines.

3.2 Initialization Screen

On the Initialization screen, the CFAST input file to be edited with CEdit is selected in one of three ways.

```
CFAST V 1.6                    Initialization                    09/30/92


                 FILE: PRM.DAT

















 |help|FILE|    |    | 1R | 3R |    |    |keys|quit|  input=>
```
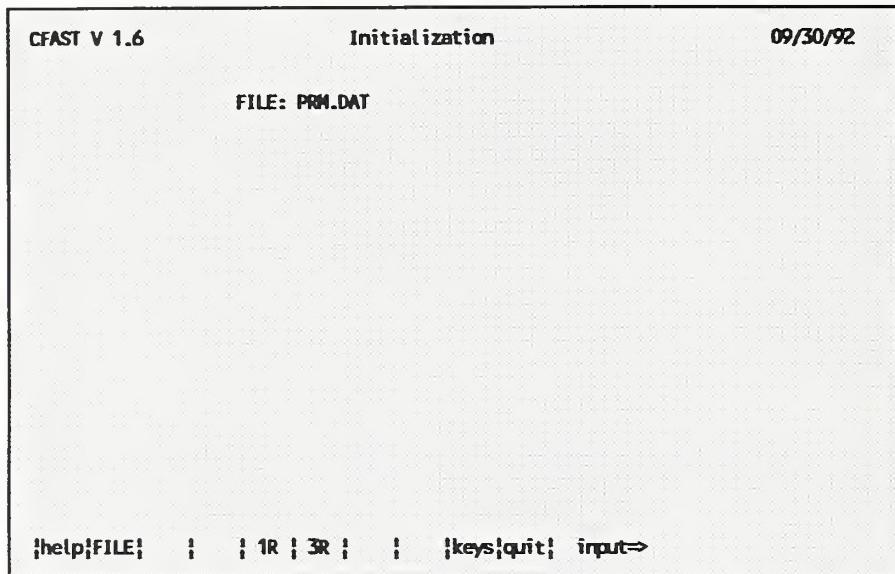
If the file desired was the last file used by CEdit or the file name was entered on the command line, press Enter to select that file automatically. Alternatively, the name of any existing DOS file may be selected directly by typing in the name of the file. To use the existing example file, type PRM.DAT, and press Enter.

```
CFAST V 1.6                    Initialization                    09/30/92

 1RTEST.DAT
 2STORY.DAT         FILE: PRM.DAT
 3RCORR.DAT
 3RTEST.DAT
 BURN.DAT
 CLOSERM.DAT
 CLOSERM2.DAT       There are   28 files in this directory
 D1A.DAT
 D1C.DAT
 D2.DAT
 D3.DAT
 DEMOF1.DAT
 DOORJET.DAT
 FM21.DAT
 HULVUL3.DAT
 MULTI.DAT
 NOCONECT.DAT
 NOFIRE.DAT
 OBJT1.DAT
 OBJT2.DAT
 Using the data path \CFAST1P5\BIN\DATS

 <esc> to exit,  <enter> to select a file
```
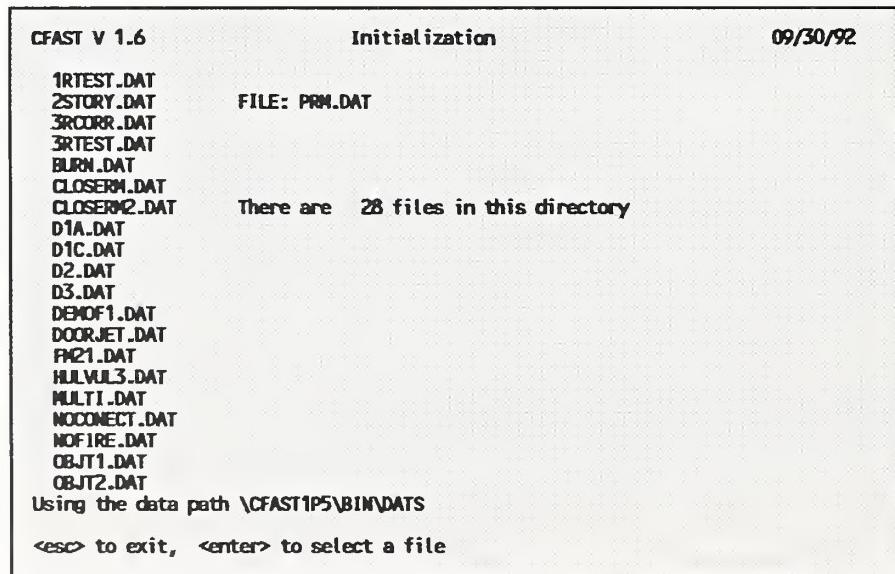
An alternative to entering the file name is to press the select file key, f2, to see a list of files in the current working directory. By default, all files with an extension of .DAT are included in the list. If desired, one may type a file matching pattern (such as *.* to see all files in the subdirectory) before pressing f2. The same rules for wildcards apply here as they do to all DOS file commands.

In addition to showing the name of the current screen, "Initialization" in this case, the name of the module, the version number and the current date are shown. The latter two can change, as CEdit is enhanced, and when run on dates different than shown in the figure.

If a completely new data file is to be created, one of two generic data sets built into CEdit may be selected. Key f5 may be pressed to use a single compartment case and key f6 may be pressed to use a three compartment case.

3.3 Overview Screen

```
CFAST V 1.6                     Overview                    09/30/92

File: PRM.DAT      Title: Example Case for CFAST 1.6 User's Guide

Geometry                   Time           Ambient Conditions    (external)

 Compartments     2 Simulation     200   Temperature  300.00      300.00
    Doors,...      2     Print      10      Pressure 1.0E+05      1.0E+05
 Ceiling vents    1   History       10   Station elv.     0.0        0.0
    MV connects   2   Display        0   Wind speed                  0.0
                      Restart        0   Ref. height               10.00
                                         Power law                0.1600
 Fire Specification

              Type Specified fire(constrained)
    Species tracked    O2  CO2   CO  HCN  HCL  TUHC  H2O    CO
        Ceiling jet CEILING




Range: Alphanumeric ( 50)    Units: Name or Title
|help| go |    |    |    |    |   |unit|keys|quit|  input=>ST 1.6 User's Guide
```

The Overview screen presents a summary of the CFAST data file. The title, simulation time, print interval, history interval, display interval, and restart time may be changed on the screen. All other information displayed is changed on other screens in CEdit and is included here (in the "protected text" color) to provide a summary of the data set. Key words in the data file effected by these changes include VERSN, TIMES, and RESTR.

3.4 Ambient Conditions Screen

```
CFAST V 1.6                    Ambient conditions                  09/30/92

                   (internal) (external)

        Temperature  300.00        300.00
          Pressure 1.0E+05        1.0E+05
        Station elv.    0.0           0.0

         Wind speed                  0.0
         Ref. height                10.00
          Power law                0.1600

        Compartments      2    Maximum pressure differential    26.53
           Doors,...      2       Maximum elevation change       4.60
        Ceiling vents     1          Total internal volume      73.60
          MV connects     2




        Range:    200.00 to   350.00  Units: Temperature in KELVIN
        |help| go |    |    |    |    |    |unit|keys|quit|  input=>
```

On the Ambient Conditions screen, the internal and external ambient temperature, pressure, and station elevation along with information on external wind may be changed. The wind speed, scale height, and power law are used to calculate the wind coefficient for each vent connected to the outside. The wind velocity is specified at some reference height. The power law then provides a lapse rate for the wind speed. An assumption is that the wind speed is zero at the surface. The formula used to calculate the wind speed at the height of any vent is (wind speed) · ((vent height)/(scale height))$^{(power\ law)}$. The wind is applied to each external opening as a change in pressure outside of the vent. It is further modified by the wind coefficient used for the openings. The vent connections, entered on the two vent screens, are summarized here along with the geometry of the structure and the mechanical ventilation connections. This summary information together with additional information concerning pressure, elevation and volume is displayed as an aid to data entry. Changes on this screen effect the TAMB, EAMB, and WIND key words when the data file is saved.

3.5 Geometry Screen

```
CFAST V 1.6                    Geometry                    09/30/92

              Dimensions

Compartment Number:        1      2
            Width:      4.00   4.00
            Depth:      4.00   4.00
           Height:      2.30   2.30
   Floor elevation:      0.0   2.30












Range:      0.0 to   150.00   Units: Distance in METER
|help| go |    |ADD |DEL |   |   |unit|keys|quit|  input=>
```

On the Geometry screen, information on the sizes of all of the compartments is entered. The key words associated with this screen are WIDTH, DEPTH, HEIGH, and HI/F. The DELETE key (f5) may be used to delete a compartment.

```
CFAST V 1.6                    Geometry                    09/30/92

              Dimensions

Compartment Number:        1      2
            Width:      4.00   4.00

    Floor |Compartment #                              3

          |Width

          |Depth (breadth)

          |Interior height

          |Height of floor above reference level
          |(reference is specified in "Ambient")



Range:      0.0 to   150.00   Units: Distance in METER
<esc> to exit, <f2> accept data                  input=>
```

Compartments may be added to the simulation with the ADD key (f4) on the Geometry screen. Dimensions of the compartment, along with the height of the compartment floor above the reference height (specified on the Ambient Screen) are entered in the overlaid window.

3.6 Vents(doors,...) Screen

```
CFAST V 1.6                    Vents(doors,...)                    09/30/92

              Dimensions

Compartment Number:         1       2
              Width:     4.00    4.00
              Depth:     4.00    4.00
             Height:     2.30    2.30
    Floor elevation:      0.0    2.30

              Vents(doors,...)

      with respect to first room    wrt second room    - absolute -
  #  width   sill  soffit  wind   #   sill   soffit   a_sil  a_sof  Vent(1->4)
  1  1.07    0.0    2.0     0.0   3    0.0     2.0     0.0    2.0        1
  2  1.07    1.0    2.0     0.0   3    3.3     4.3     3.3    4.3        1




Range:      0.0 to    4.00   Units: Distance in METER
```

On the Vents(doors,...) screen, all horizontal flow connections between compartments and openings to the outside are specified. A vent may be added using the ADD key (f4) or deleted using the DELETE key (f5). The OPEN/CLOSE key (f6) allows specification of the vent position over the course of the fire for the currently selected vent.

```
CFAST V 1.6                    Vents(doors,...)                    09/30/92

              Dimensions

Compartment Number:         1       2
              Width:     4.00    4.00

       Floor |First Compartment                          |
             |                                           |solute -
             |Second Compartment                         |l  a_sof  Vent(1->4)
      with   |Vent number                                |        2.0        1
  #  widt    |                                           |        4.3        1
  1   1.0    |Width                                      |
  2   1.0    |                                           |
             |Soffit (with respect to first comp)        |
             |                                           |
             |Sill (with respect to first comp)          |
             |                                           |
             |Wind                                  0.0  |

Range:        1 to     3   Units: Compartment number
<esc> to exit, <f2> accept data                    input=>
```

Like adding a compartment on the geometry screen, the ADD key (f4) may be used on the Vents(doors,...) screen. A vent is specified by the two connecting compartments, the vent number, and the size and location of the vent. A connection to the outside is defined by using a

compartment number for the "Second Compartment" one greater than the total number of
compartments entered on the Geometry screen. Each entry on this screen creates the appropriate
HVENT key word in the data file.

```
CFAST V 1.6                 Open/Close Vents              09/30/92


        Vent # 1 from compartment # 2 to # 3

                              1.00 *                              *
   ┌──────────────┐
   │ 1    1.00    │               |
   │ 2    1.00    │               |
   └──────────────┘               |
                            0.5000 +
                                   |
                                   |
                                   |
                              0.0 +--------+--------+--------+--------+--------+
                                  0.      80.     160.     240.    320.     400.



Range:   0.0  to  1.0
<esc> to exit,  <f1> for help                       input=>
```
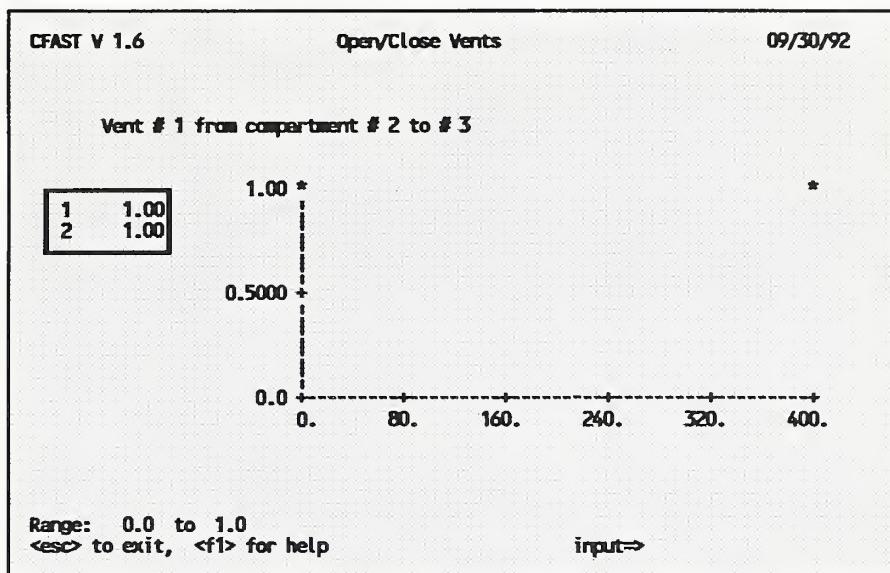
The OPEN/CLOSE positions for any vent can be specified by moving the highlight bar to
that vent on the main vents screen and pressing the f6 key. The current timeline values
(horizontal axis on the graph above) for the selected vent are displayed. Move the highlight bar
to the entry to be changed and enter a value from 0 (closed) to 1 (completely open). The default
value is 1. This entry is applied in CFAST by multiplying the width of the vent by this value.
The number of possible entries on this screen is determined by the number of specified points on
the timeline which is specified the Fire Specification screen. For a more complete explanation of
the timeline, please read the section in Fire Specification about modification of the duration of the
fire. These OPEN/CLOSE events are always related to the course of the fire. One CVENT key
word is created in the data file for each complete entry.

3.7 Vents(ceiling,...) Screen

```
CFAST V 1.6                    Vents(ceiling,...)                    09/30/92
                Dimensions

Compartment Number:        1      2
            Width:      4.00   4.00
            Depth:      4.00   4.00
           Height:      2.30   2.30
   Floor elevation:      0.0    2.30

                Vents(ceiling,...)

  - compartment -                        - relative -    - absolute -
     top     bottom     shape      area      height         height
      2         1         C        1.00       2.30           2.30




                              Units:  C or S
  |help| go |     |ADD |DEL |     |    |unit|keys|quit|  input=>
```

On the Vents(ceiling,...) screen, all vertical flow connections between compartments and openings to the outside are specified. A vent may be added using the ADD key (f4) or deleted using the DELETE key (f5). Vertical flow entry does not provide an equivalent to CVENT to allow specification of the vent position over the course of the fire.

```
CFAST V 1.6                    Vents(ceiling,...)                    09/30/92
                Dimensions

Compartment Number:        1      2
            Width:      4.00   4.00
            Depth:      4.00   4.00
           Height:      2.30   2.30
   Floor elevation:      0.0    2.30


  - compar| Top Compartment                        |lute -
     top  |                                         |ght
      2    | Bottom Compartment                     |.30
           |
           | Shape
           |
           | Area


Range:        1 to      3   Units: Compartment number
<esc> to exit, <f2> accept data                    input=>
```

Vertical flow vents may be added by using the ADD key (f4) on the Vents(ceiling,...) screen to create VVENT key words in the data file. The vent is specified by the upper and lower connecting compartments, the shape of the vent (Circle or Square), and the area of the vent. A

connection to the outside is permitted for either the "Top Compartment" or the "Bottom Compartment". Such a connection is defined by entering a compartment number one greater than the total number of compartments on the Geometry screen. The upper compartment can not have a floor height lower than the ceiling of the lower compartment and must be within 0.1 meters of the ceiling height for the lower compartment.

3.8 Fans, Ducts,... Screen

```
CFAST V 1.6                    Fans, Ducts,...                    09/30/92
                  Dimensions

Compartment Number:       1        2
              Width:    4.00     4.00
              Depth:    4.00     4.00
             Height:    2.30     2.30
     Floor elevation:    0.0     2.30

             Exterior Connections

Compartment      # node      Orientation      Height         Area

     1             1             V             2.10          0.12
     2             3             V             2.10          0.12




                          Units:  H or V
 |help| go |    |ADD |DEL |DUCT|FAN |unit|keys|quit|  input=>
```

Mechanical ventilation systems are entered using this screen. This includes details of the connections from compartments to the ventilation system, and of the ductwork and fans within the system. These are specified on the three separate pages of the Fans, Ducts screen. On this first page, the connections between compartments and the ventilation system are detailed. These correspond to the MVOPN key word in the CFAST data file. Like the Geometry and Vents screens, these connections may be added with the ADD key (f4) or deleted with the DELETE key (f5). The DUCT key (f6) allows specification of the ductwork on the Duct page. The FANS key (f7) allows specification of the operating characteristics of the fans in the system.

```
CFAST V 1.6                    Fans, Ducts,...              09/30/92
               Dimensions
Compartment Number:      1      2
              Width:    4.00   4.00

   Floor  Compartment Number

          Node Number

   Compartm Orientation ( H or V )                          Area

      1     Height of midpoint                              0.12
      2                                                     0.12
          Area



Range:        1 to      6  Units: Compartment number
<esc> to exit, <f2> accept data                    input=>
```

Connections from compartments to the ventilation system are added using the ADD key (f4) from the main mechanical ventilation screen. A connection is fully specified by the compartment number, mechanical ventilation node number, orientation (Horizontal or Vertical), height, and area.

```
CFAST V 1.6                    Fans, Ducts,...              09/30/92
                              Duct Work
         node                 abs      expanded        node
    1st   2nd    len    diam  rough  joint1 joint2  hght1 hght2
     1     2    2.30    0.10  0.0020  1.00   1.00    2.10   4.40




Range:      0.0 to   300.00  Units: Distance in METER
<esc> ¦    ¦ ¦ADD ¦DEL ¦   ¦    ¦unit¦keys¦   ¦ input=>
```

The ductwork in the ventilation system is specified on the Duct page by pressing f6 from the main screen. Internal connections may be added with the ADD key (f4) or deleted with the DELETE key (f5). Pressing Page Up will return to the main screen.

```
CFAST V 1.6                    Fans, Ducts,...              09/30/92
                              Duct Work
        node                   abs      expanded         node
   1st   2nd   len   diam    rough   joint1 joint2   hght1  hght2
    1     2    2.30  0.10    0.0020   1.00   1.00     2.10   4.40
        ┌─────────────────────────────────────────────┐
        │Node 1 number                                 │
        │Node 2 number                                 │
        │Length                                        │
        │Diameter                                      │
        │Absolute Roughness                            │
        │Flow Coefficient Node 1              0.0      │
        │Expanded Area of Joint Node 1        1.00     │
        │Abs. Elevation Node 1                         │
        │Flow Coefficient Node 2              0.0      │
        │Expanded Area of Joint Node 2        1.00     │
        │Abs. Elevation Node 2                         │
        └─────────────────────────────────────────────┘



Range:       1 to     176  Units: integer
<esc> to exit, <f2> accept data              input⇒
```

The ADD key on the Duct page creates a window to specify a connection between internal nodes of the mechanical ventilation system. All of the information for the MVDCT and INELV key words in the CFAST data file are entered for a single connection.

```
CFAST V 1.6                    Fans, Ducts,...              09/30/92
        Fan Setup    Number of Fans 1
  Fan # Node 1 Node 2   Pmin : Flow   Pmax : Flow   No. Coeff
    1      2      3      0.00  0.1400  300.00 0.0101    2


   Head    Flow  0.2000 +                           Coefficient
    0.0   0.1400        |                             0.140E+00
   75.00  0.1075        |                            -0.433E-03
  150.00  0.0750        *
  225.00  0.0426        |
  300.00  0.0101 0.1000 +        *
                        |              *
                        |                   *
                        |                        *
              0.0 +-----+------+------+------+
                  0.    75.   150.   225.  300.

Range:       1 to     1  Units: integer
<esc>|   | |ADD |DEL |   |   |unit|keys|  | input⇒
```

Operating characteristics of the fans in the ventilation system are specified on the Fan setup page. Fans may be added with the ADD key (f4) or deleted with the DELETE key (f5). Once a fan has been added to the system, the fan curve may be modified by either entering a set of pressure and flow data or a set of coefficients for the fan curve. In either case, CEdit will calculate the other quantity before leaving the Fan setup page. Pressing Page Up will return to the main screen.

```
CFAST V 1.6                    Fans, Ducts,...                    09/30/92
           Fan Setup   Number of Fans 1
     Fan # Node 1 Node 2   Pmin :  Flow    Pmax :  Flow    No. Coeff
       1      2      3     0.00   0.1400   300.00  0.0101      2

            ┌─────────────────────────────────────────────┐
            │ Node 1 Number                               │
            │                                             │
     Head   │ Node 2 Number                               │  Coefficient
     0.0    │                                             │  0.140E+00
     75.00  │ Minimum Pressure                            │  -0.433E-03
     150.00 │                                             │
     225.00 │ Flow at Min Pressure                        │
     300.00 │                                             │
            │ Maximum Pressure                            │
            │                                             │
            │ Flow at Max Pressure                        │
            │                                             │        *
            │ Fan Coefficients will be calculated         │ ----+
            └─────────────────────────────────────────────┘  300.
  Range:        1 to      100   Units: integer
  <esc> to exit, <f2> accept data                    input⇒
```

New fans are added to the system using the ADD key (f4) from the Fans page. A fan is specified by entering internal node numbers, minimum and maximum pressures, and flow at each pressure. A MVFAN key word is created for each entry on this page when the data file is saved.

3.9 Thermal Properties Screen

```
CFAST V 1.6                  Thermal properties                  09/30/92
              Dimensions

  Compartment Number:      1        2
             Width:     4.00     4.00
             Depth:     4.00     4.00
            Height:     2.30     2.30
    Floor elevation:     0.0     2.30

            Thermal properties from THERMAL.DF

  Ceiling properties:  GYPSUM   GYPSUM
    Floor properties: CONCRETE CONCRETE
     Wall properties: PINEWOOD PINEWOOD




  Range: Alphanumeric ( 8)    Units: Name or Title
  |help| go |FILE|ADD |OFF |DATA|   | |keys|quit|  input⇒
```

The Thermal Properties screen details the materials used for the ceiling, walls, and floor of each compartment. The name of a material contained in the CFAST Thermal Database may be entered by first positioning the highlighted selection bar over the entry of interest and typing the material name exactly as it exists in the database. To make the process easier, a material name

may be selected on the Thermal Database page below for the currently highlighted surface. Once a material has been selected on the Database page, it can be designated for additional surfaces by selecting the desired surface and pressing the ADD PICKED key (f4). To specify an adiabatic surface, press the OFF key (f5) to turn OFF the heat transfer calculation for that surface. If the word NONE is displayed for a material, it means that the name entered does not appear in the Thermal Database. Key words associated with this screen include CEILI, WALLS, and FLOOR.

```
CFAST V 1.6                    Thermal Database                    09/30/92

         Conduct Specifi Density Thickne Emissiv      * CODES *
DFIR30M   0.0002  0.9000  790.00  0.0160  0.9000
PINEWOOD  0.0001  2.50    540.00  0.0160  0.8000       60    U
CONCRETE  0.0018  1.00    2200.0  0.1500  0.9400       188   U
REDOAK    0.0002  1.30    640.00  0.0160  0.9000
FIBERB    0.0     1.25    240.00  0.0160  0.9000
WOOD      0.0     1.00    250.00  0.0160  0.9800
DFIROM    0.0001  1.40    510.00  0.0130  0.9900
DFIR10M   0.0002  1.50    560.00  0.0160  0.9000
LIMEGLAS  0.0014  0.7600  2500.0  0.0160  0.9500
GLASFIBR  0.0     0.7200  32.00   0.0880  0.9000
KAOWOOL   0.0002  1.05    128.00  0.1160  0.9700
GYPSUM    0.0002  0.9000  790.00  0.0160  0.9000       38    U
GYP1/2    0.0002  0.9000  790.00  0.0130  0.9000
GYP3/4    0.0002  0.9000  790.00  0.0190  0.9000
GYPX5/8   0.0001  0.9000  770.00  0.0160  0.9000
BRICK     0.0002  0.9000  790.00  0.0760  0.9000
GLASS     0.0014  0.7600  2500.0  0.0060  0.1000
FC1_L003  0.0002  1.50    790.00  0.0160  0.9000             I


¦help¦   ¦   ¦   ¦   ¦PICK¦   ¦unit¦keys¦   ¦  <esc> to exit
```

The DATA key (f6) displays the CFAST Thermal Database from the Thermal Properties screen. The contents of the database may be examined, and a material can be chosen (and later added in the Thermal Properties screen) by positioning the highlighted selection bar over the material and pressing the PICK MATERIAL key (f6). Press the Page Up and Page Down keys to quickly browse through the database. Move to the first database entry by pressing the Home key or the last entry by pressing the End key. The thermophysical database can not be changed by CEdit.

```
CFAST V 1.6              Thermal properties              09/30/92

              Dimensions

Compartment Number:        1        2
            Width:      4.00     4.00
            Depth:      4.00     4.00
           Height:      2.30     2.30
  Floor elevation:       0.0     2.30

              Thermal properties from THERMAL.DF

Ceiling properties:  GYPSUM   GYPSUM
  Floor properties: CONCRETE CONCRETE
   Wall properties: PINEWOOD PINEWOOD




Range: Alphanumeric ( 8)    Units: Name or Title
<esc> to exit, <f1> for help                input=>thermal2.df
```

An alternate CFAST Thermal Database can be specified by pressing the FILE key (f3) from the Thermal Properties screen. Enter the alternate database file name and press Enter, or press Esc to leave the name unchanged. Materials selected previously which are not found in the new database are set to NONE and redisplayed. The new database file name becomes the Thermal Database for this input file only. If this file name differs from the database specified in the configuration file (see CF_Set), the THRMF key word is added to the input file when it is saved. It is important to note that once an alternate database has been specified, this database must be available when the model is run with this data input file.

3.10 Fire Specification Screen

```
CFAST V 1.6              Fire Specification              09/30/92

  Heat of C   Lim O2  Rel Hum.   GMW    Pos   Room   Type   CJET
   1.8E+04    10.00     0.0     16.00           1     2     OFF

 ┌──────────┐  2.0E+04 +
 │1  1.8E+04│           *                                        *
 │2  1.8E+04│           |
 └──────────┘           |
                        |
             1.0E+04 +
                        |
                        |
                        |
                 0.0 +---------+---------+---------+---------+---------+
                        0.       80.      160.     240.     320.     400.

   Pyrolysis Heat_release  Height  Area  H/C O2 CO/CO2 C/CO2 HCN HCL Ct

Range:  0.0010 to  6.0E+04   Units: Heat of Combustion in KILOJOULE/KILOGRAM
 |help| go |     |ADD |DEL |MOD |     |unit|keys|quit|   input=>
```

All data pertaining to the combustion properties of the main fire are entered on this screen. The heat of combustion, mass loss rate, and species yields are entered, along with selection of the fire compartment and fire type as described in the data file format section. The number of possible entries for each time dependent variable is determined by the number of specified points on the fire timeline below. Note that fire chemistry is only allowed for constrained (type 2) fires. The ceiling jet option can be set by moving to the ceiling jet entry and using the arrow keys to highlight the desired option. The default value for ceiling jet is OFF. Data file key words for this screen include LFBO, LFBT, CHEMI, FPOS, FMASS, FHIGH, FAREA, FQDOT, and CJET. Individual objects may be entered on the Objects screen below.

Note that a time history for the heat of combustion is only available if a time history has been entered for both the mass loss rate and the rate of heat release. Any value entered directly for the heat of combustion is a constant value throughout the simulation. If you have time dependent values available for the mass loss rate and rate of heat release, enter these values and CEdit will calculate the corresponding time history for the heat of combustion.

If the fire compartment for an existing data file is changed, the fire position is recalculated so that the relative position in the original compartment is maintained in the new compartment. If the fire compartment was not set previously, the fire is positioned in the center of the specified compartment. See Section 6.2.8 for an explanation of the coordinate system used in specifying the position of the fire. A zero (0) entry for the compartment indicates no main fire leaving only object fires specified on the Objects screen below.

A species may be added to the calculation using the ADD key (f4) or deleted from the calculation using the DELETE key (f5) after moving the highlight bar to the desired species. Each species added to the calculation is represented in the data file by a unique key word.

```
CFAST V 1.6              Modify Time Interval              09/30/92



            The time line shows the relative size of the time intervals
       ┌─────────────┐
       │ 1     0.0   │
       │ 2   400.00  │   *--------------------------------------------------*
       └─────────────┘



                    Press <f4> to insert a time point

                    Press <f5> to delete the time point




Range:    1.00 to 8.6E+04   Units: Time in SECOND
<esc> to exit, <f1> for help, <f8> to change units    input=>
```
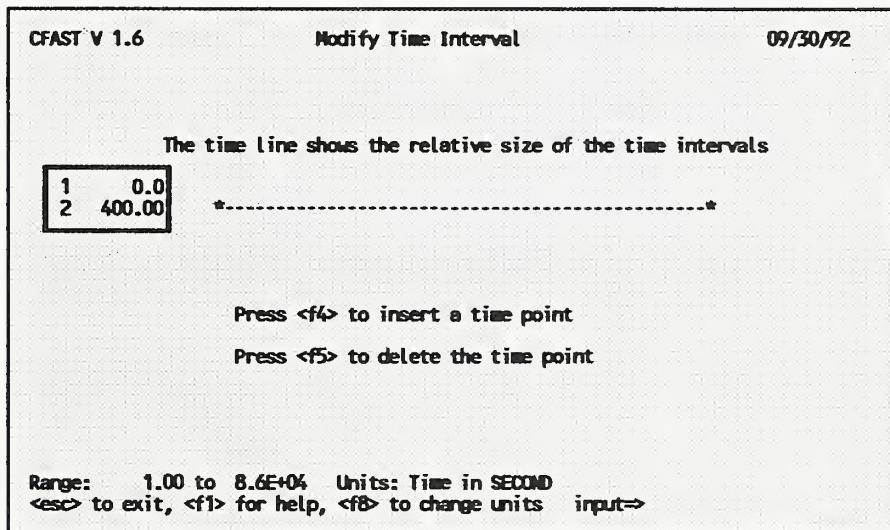
The FTIME time points in the data file may be modified by pressing the MODIFY TIME key (f6) from the Fire Specification screen. The timeline is modified by adding new points with

the ADD (f4) key, deleting existing points using the DELETE (f5) key, or pointing to an entry and entering a new value. When the ADD key is pressed, a new point is created with a value that splits the time interval between the currently highlighted point and the previous one into two equal intervals, i.e., the midpoint of the interval.

3.11 Objects Screen

```
CFAST V 1.6                        Objects                        09/30/92

            Dimensions

Compartment Number:         1      2
              Width:     4.00   4.00
              Depth:     4.00   4.00
             Height:     2.30   2.30
    Floor elevation:      0.0   2.30

                 Objects selected from OBJECTS.DF

                                              ———— Position ————
Name      Compartment   Start time   First element      X      Y      Z
SOFA          1             10            1           4.00   2.00   0.00
WARDROBE      1             30            3           0.00   2.00   0.00




Range: Alphanumeric (  8)    Units: Name or Title
|help| go |FILE|ADD |DEL |DATA|    |unit|keys|quit|  input⇒
```

Objects to be burned in the fire scenario can be specified on the Objects screen. Any object name found in the CFAST Objects Database may be entered. Objects may be added with the ADD key (f4) or deleted with the DELETE key (f5). The DATA key (f6) displays the current objects database and provides an easy method for object selection. An alternate database can be specified by pressing the FILE key (f3).

```
CFAST V 1.6                    Objects                    09/30/92
              Dimensions
Compartment Number:        1      2
             Width:     4.00   4.00

     Floor | Name
           |
           | Compartment #              TS.DF
           |
           | Start Time                 ——— Position ———
  Name     | First Element         nt     X      Y      Z
  SOFA     |                            4.00   2.00   0.00
  WARDROBE | X                          0.00   2.00   0.00
           |
           | Y
           |
           | Z

Range: Alphanumeric ( 8)     Units: Name or Title
<esc> to exit, <f2> accept data, <f6> pick          input⇒
```

The ADD key (f4) on the Objects screen uses an overlaid window to specify a new object. Entry includes the object name, compartment, and the object position. The object position uses a similar x, y, z coordinate system to the fire position on the Fire Specification screen. The first element entry indicates where on the object ignition begins, however, it is not used by the model at this time. Entry is required for future compatibility with the CFAST model. A value of 1 should be entered unless a different value is known. In addition, a time should be entered indicating the earliest time during the simulation that the CFAST model should check the fire scenario to determine if conditions have been met for the object to begin burning. If the flux to the object and the surface temperature are high enough beyond this time in the simulation, the object starts to burn. Each complete entry on this screen creates an OBJECT entry in the data file.

```
CFAST V 1.6                 Objects Database                 09/30/92

                                            ——————— PANEL ———————
              Type  Ignition Temp   Length   Width   Thickness  # Elements
  TABLE        2       273.00        1.00     1.00     0.20         9
  DESK         2       273.00        1.00     1.00     0.20         9
  SOFA         2       300.00        1.00     1.00     0.20         9
  WARDROBE     2       300.00        1.00     1.00     0.20         9

  |help|   |   |   |   |PICK|   |unit|keys|   |  <esc> to exit
```

The contents of the CFAST Objects Database may be examined, and an object can be selected by positioning the highlighted selection bar over the object and pressing the PICK OBJECT key (f6). This is available in both the Add Objects window and the main Objects screen. Press the Page Up and Page Down keys to quickly browse through the database. Move to the first database entry by pressing the Home key or the last entry by pressing the End key. The objects database can not be changed by CEdit.

```
CFAST V 1.6                      Objects                        09/30/92

              Dimensions
    ┌──────────────────────────────────────────────────────────────────┐
 Compa│ Any of the objects below which are not found in OBJECTS2.DF will │
    │ be deleted.  Are you sure you want to complete this change?       │
    └──────────────────────────────────────────────────────────────────┘

          Height:      2.30    2.30
    Floor elevation:    0.0    2.30

                  Objects selected from OBJECTS.DF

                                            ──────── Position ────────
    Name      Compartment   Start time  First element      X       Y       Z
    SOFA          1             70           1           4.00    2.00    0.00
    WARDROBE      1            100           3           0.00    2.00    0.00




    Range: Alphanumeric ( 8)    Units: Name or Title
       Yes or No                                        input=>
```

An alternate CFAST Objects Database can be specified in a manner similar to the Thermal Properties Database by pressing the FILE key (f3) from the Objects screen. Enter the new database file name and press Enter, or press Esc to leave the name unchanged. If any of the objects specified previously are not found in the new database, a warning message is displayed. Respond "Y" to the warning message only if it is acceptable to have undefined objects deleted. If the new database file name is accepted, it becomes the Objects Database for this input file only. The OBJFL key word is added to the data file when it is saved if this file name differs from the one specified in the configuration file (see CF_Set). It is important to note that once an alternate database has been specified, this database must be available when the model is run with this data input file.

3.12 Files,... Screen

```
CFAST V 1.6                    Files,...                    09/30/92


        quick estimates       <f5> asks for a time interval
        run time graphics     <f6> use existing display file (if it exists)
        save data file(s)     <f7>
        write to log file     <f8> no







    help  go                              quit
```
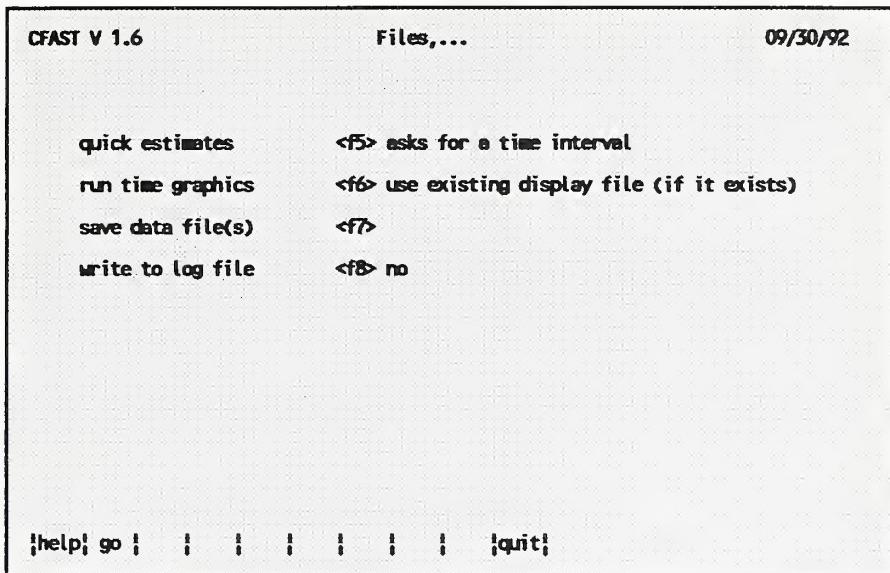
The Files screen is used to specify the file name for the input file and to access some additional options. If problems are encountered within CEdit, you can document the problem by generating a log file with the f8 function key and repeating the sequence of commands which generated the problem. Append a simple graphics descriptor to the CFAST data file by pressing f6 on the Files screen. The resulting display will show selected variables in a simple X-Y plot on the screen as the CFAST model calculates the results. Pressing f6 again indicates that any graphics descriptors currently in the data file are to be rewritten to the data file when it is saved. The graphics descriptors in the current data file can not be modified using CEdit but must be modified using an ASCII text editor.

```
CFAST V 1.6                      Files                        09/30/92

*    Main data file to run    PRM.DAT

     History file             PRM.HI

     Restart file             no file specified

     Thermal properties file  THERMAL.DF

     Objects data file        OBJECTS.DF

     a * indicates that the file has been modified and not saved

   ┌──────────────────────────────────────────────────────────────┐
   │ Use the cursor keys to point to the file to be saved.  Then press <enter>. │
   │ To change the file name, enter a new name and press <enter>.   │
   └──────────────────────────────────────────────────────────────┘
```

Once data for a test case has been entered or modified using CEdit, you should save the data to disk to run with the CFAST model. To save the data to a disk file, press f7. Type the file name and press Enter. The output from the CFAST model may be written to a disk file for further processing by programs such as CPlot or to restart CFAST. The DUMPR and RESTR data file key words are created for the corresponding entries on this screen. File names for the Thermal and Objects Databases are displayed as summary items and can not be changed on this screen. To change these database file names, you must use the FILE option on the appropriate Thermal Properties or Objects screen.

3.13 Version and Settings Screen

```
CFAST V 1.6              Version and Settings                 09/30/92

   ┌────────────────────────────────────────────────────────────────┐
   │ The current version of CFAST is 1.6                              │
   │                                                                  │
   │ The modules which reflect this are                               │
   │                                                                  │
   │  CFAST, CEdit, CF_Set, Report, ReportG, CPlot, and Survival.     │
   │                                                                  │
   │ Permanent changes can be made for the colors and units which     │
   │ are used by these programs.  These  changes are then saved in     │
   │ the configuration file and will be used the next time one of the  │
   │ above programs is used.  The path for data files, and the name    │
   │ of the thermophysical and other data files can not be changed     │
   │ here, but only by rerunning the installation program.            │
   └────────────────────────────────────────────────────────────────┘

                    To change colors        <f4>
                    To change units         <f5>
                    Reset colors/units      <f6>
```

The display colors and units within CEdit can be altered using the version and settings screen. Unlike the f8 key on the individual screens, the unit selection here makes the changes permanent, as would be accomplished with the CF_Set utility.

```
CFAST V 1.6                    Color Palette                    09/30/92

   ►MAIN HEADING

    SUB HEADING

    NORMAL TEXT
    PROTECTED TEXT
                              ┌─────────────────────┐
    MESSAGE OUTPUT            │This is a sample of the│
                             │help message text screen.│
    ERROR MESSAGE            │Usually it will have the│
                             │same background as that│
    NORMAL BACKGROUND       │used for the messages and│
    MESSAGE BACKGROUND      │error codes.            │
    HELP BACKGROUND         └─────────────────────┘
    ERROR BACKGROUND


              ┌──────────────────────────────────────┐
              └──────────────────────────────────────┘
                ↑                         ↑
```
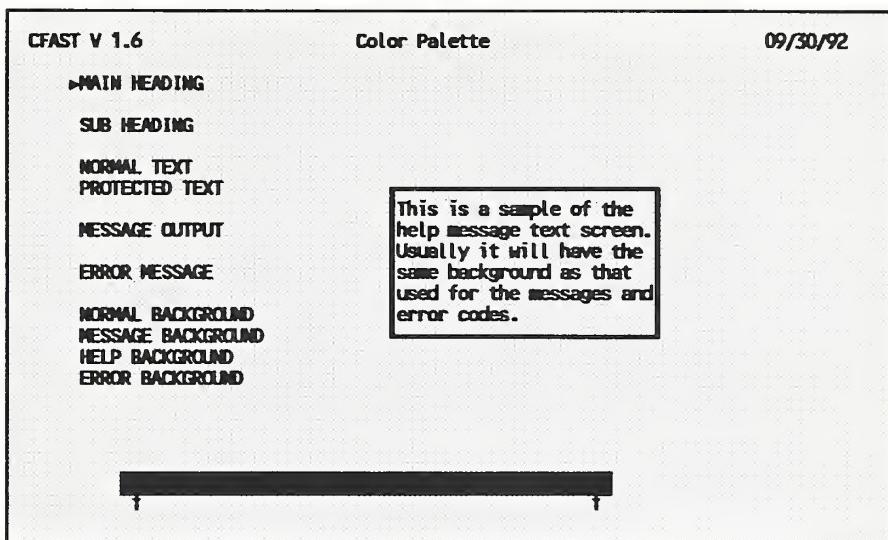
Any or all of the colors used by CEdit for screen displays may be changed. Use the arrow keys up and down to select the type of display text to be changed and the right and left arrow keys to select the color for the foreground or background. The defaults have been selected to produce acceptable displays on both monochrome and color displays.

```
CFAST V 1.6                      Set Units                      09/30/92

  Base Units     Current Units  Possible Units

  Temperature    KELVIN         KELVIN    CELSIUS    RANKINE    FAHRENHEIT

  Pressure       PASCAL

  Length         METER

  Energy         KILOJOULE

  Mass           KILOGRAM

  Time           SECOND

  Time           SECOND


  ┌──────────────────────────────────────────────────────────────┐
  │To change units, highlight the basic unit to be changed, then point to the│
  │unit desired.  Pointing is done either with the cursor keys or the mouse.│
  └──────────────────────────────────────────────────────────────┘
```
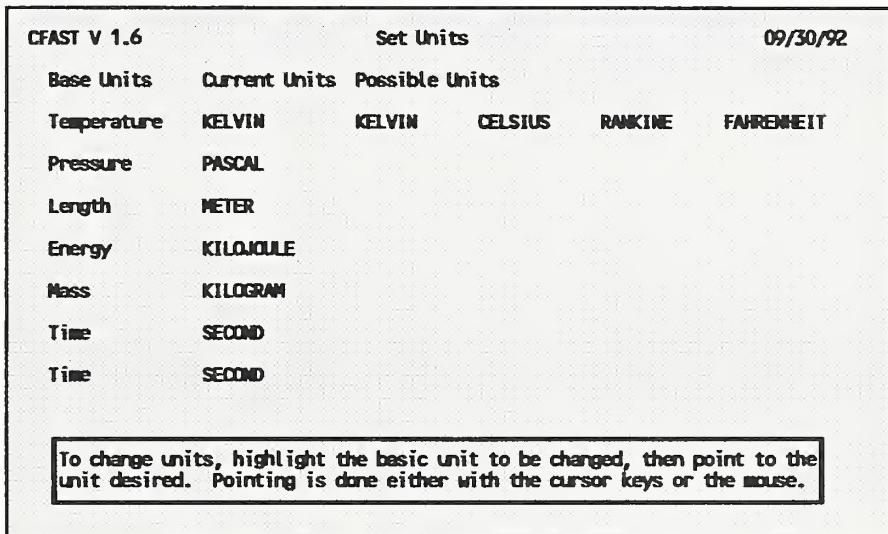
As supplied, most of the engineering units used for interactive input and display by CEdit are standard SI units. Energy defaults to kJ since rates of energy release are typically specified in kJ/s (kiloWatts). Use the up and down arrow keys to select the unit to change and the left and

right arrow keys to change the units. This screen is also available from each of the main screens in CEdit by pressing the UNIT key (f8).

3.14 Quitting CEdit


```
┌────────────────────────────────────────────────┐
│One or more of the data files have been altered │
│and not saved.  Do you want to quit anyway?     │
└────────────────────────────────────────────────┘
```

Yes or No   input=>
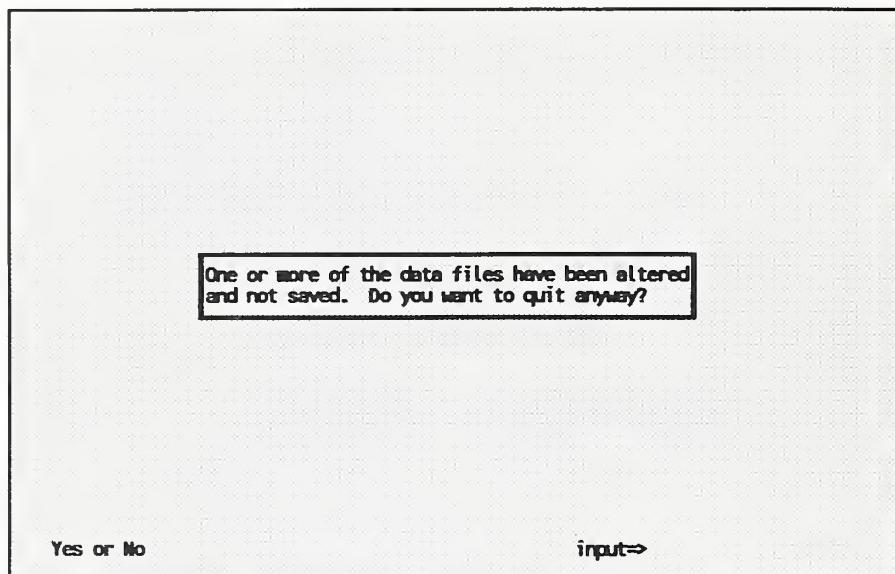
When data entry for the input file is finished, press the QUIT (f10) key from any main screen. If changes have been made without saving, a warning window is displayed. Enter Y and press Enter to quit without saving current changes. Respond N to return to CEdit, then press the END key to access the Files screen.

4. CFAST

The output of the CFAST program consists of two major parts. The first is a summary of the input data and the initial conditions. The second consists of the calculated results at the end of each print interval. The particular example comes from PRM.DAT explained in the chapters on CEdit. Due to the effect of the computer's internal precision on the solution of the equations, it is possible that the results from other computers will differ slightly from those found below. The output is labeled and most of it is self explanatory. There are, however, several abbreviations used which are explained in the following sections along with a general description of the output. The output pertaining to each of the compartments is listed across the page beginning with compartment one in the left most column and proceeding to the right to the highest number compartment.

4.1 Using CFAST

There are several ways to run CFAST. If CEdit has already been used to set up a file, all that is needed is to enter the command:

cfast

In this case, the last file used in CEdit is used as the datafile. In the case of PRM.DAT, this would not be desirable. PRM.DAT has both a graphics display as well as a request to print out the ASCII text history. Both of these default to the screen so that the text and graphics overwrite each other leading to a very messy and confusing output. To get around this problem, the command line should be:

cfast prm.dat prm.out

This allows the graphics display to be drawn to the screen and the ASCII text to be written to the output file PRM.OUT.

As was stated in Section 2.1, pressing the <f5> function key will show the current time and time step. Pressing escape will terminate the run. For example, if <f5> is pressed during the run, the following might display:

```
Time =    9.58550207410571    DT =   0.353489940990121
```

4.2 Summary of Input Data

The summary of the input data is divided into seven sections. These are geometrical data, connections between compartments, mechanical ventilation, thermophysical properties, objects, the fire specification, and the initial conditions. An overview section precedes these sections and lists the version number and any title which was in the data file. To make changes to the input file, see the section on CEdit.

4.2.1 Overview

```
CFAST version  1.6.0 - created May 15, 1992     Example Case for CFAST 1.6 User's Guide
```

4.2.2 Geometry

This section lists the total number of compartments along with the width, depth, height, area, and volume for each compartment. It also gives the ceiling and floor height with respect to the reference datum.

```
Total compartments =              2
        FLOOR PLAN
              Width      4.0    4.0
              Depth      4.0    4.0
              Height     2.3    2.3
              Area      16.0   16.0
              Volume    36.8   36.8
              Ceiling    2.3    4.6
              Floor      0.0    2.3
```

4.2.3 Vents(doors,...)

The next section is connections between the compartments. Each compartment is listed vertically down the page and horizontally across the page. The connections between compartments are given at the intersection of the vertical and horizontal lists. The final compartment in the horizontal list is the exterior space. The numbers in parentheses in the vertical compartment list are the number of openings for each compartment. For example, if the number of openings between any two compartments is three, there would be three parts for each compartment in the vertical list. Each part consists of the following:

1) opening width (m)
2) height of top of opening above floor (m)
3) height of bottom of opening above floor (m)
4) height of top of opening above reference datum (m)
5) height of bottom of opening above reference datum (m)

```
NORMAL CONNECTIONS
     1 ( 1)  Width      0.00   0.00   1.07
             Soffit     0.00   0.00   2.00
             Sill       0.00   0.00   0.00
             a.Soffit   0.00   0.00   2.00
             a.Sill     0.00   0.00   0.00
     2 ( 1)  Width      0.00   0.00   1.07
             Soffit     0.00   0.00   2.00
             Sill       0.00   0.00   1.00
             a.Soffit   0.00   0.00   4.30
             a.Sill     0.00   0.00   3.30
```

4.2.4 Fans, Ducts,...

The mechanical ventilation summary follows the data on connections. The mechanical ventilation page is broken up into three parts. The first part lists the nodes and their ducts. Like the connections, mechanical ventilation is printed out as a matrix. Down the side and along the top are the nodes that make up the system. At the intersection of two nodes, if the space is nonblank, the nodes are connected. If the values are all zero, the nodes are connected by a fan. The description of the duct connecting two nodes is the following information:

1) the length of the duct (m)
2) the area of the duct (m)
3) the absolute roughness of the duct walls (mm)

```
MECHANICAL VENTILATION (RESISTIVE) CONNECTIONS

     NODE              1     2     3 COMPARTMENT

     1    Length            2.30            1
          Area              0.01
          ARgh(mm)         20.00
     2    Length      2.30        0.00
          Area        0.01        0.00
          ARgh(mm)   20.00        0.00
     3    Length            0.00            2
          Area              0.00
          ARgh(mm)          0.00
```

The second part is the interior elevation of the nodes. This is the absolute elevation of the nodes above the reference height. The nodes are given in numeric order.

```
Interior Elevation  2.10  4.40  4.40
```

The final part of the mechanical ventilation summary is the fan connections. First there is a declaration of how many fans are in the system, and then a line of numbers describing each fan. The first number is the fan number followed by the head node, the end node, the number of coefficients in the fan curve, the minimum head pressure, the maximum head pressure, and finally the fan curve coefficients.

```
THERE IS ONE FAN CONNECTION

     1   2   3   2    0.0  300.0  0.140      -4.330E-04
```

4.2.5 Thermal Properties

This section lists the thermophysical properties of the ceiling, floor, and wall, respectively, for each compartment. The initial information specifies the names as given in the data file along with the name of the current thermal properties database. Following this is a listing of the conductivity, specific heat, density, thickness and emissivity obtained for each of the thermophysical items. Additionally, the HCl constants used to calculate the HCl deposition for a surface are displayed. The final column indicates any applicable codes. See Appendix C for a detailed explanation of these codes. If CFAST is unable to find a specified name, it will stop at this point.

```
Material names

        Ceiling:    GYPSUM    GYPSUM
        Walls:      PINEWOOD  PINEWOOD
        Floor:      CONCRETE  CONCRETE

Thermal data base used: THERMAL.DF

Name  Conductivity Specific heat   Density   Thickness Emissivity       HCL B's (1->4)              **Codes**


PINEWOOD  0.120       2.500E+03    540.      1.600E-02  0.800     0.00E+00  0.00E+00  0.00E+00  0.00E+00   U

CONCRETE  1.75        1.000E+03    2.200E+03 0.150      0.940     0.00E+00  0.00E+00  0.00E+00  0.00E+00   U

GYPSUM    0.160       900.         790.      1.600E-02  0.900     6.30E-03  1.92E+02  5.87E-02  7.48E+03
```

4.2.6 "Other Objects"

The "other objects" section summarizes information about the objects being burned in the simulation. The first line tells which data file is being used by CFAST to get the information for the objects. Then information about each object is listed. The listing of each object is in two parts. The first part lists general information about the object. This information is labelled and is as follows:

1) object name
2) reference number
3) the fire type
   1 is a free burn
   2 is a constrained fire
4) the number of intervals in the object specification
5) the time that the object should start burning (sec)
6) the minimum flux to the surface needed to start the object burning (w/m^2)
7) the minimum surface temperature to start the object burning (k)
8) the total mass of the object (kg)
9) the gram molecular weight of the object
10) the volatilization temperature (k)

The second part of the object summary is a print out of the time dependent variables. The line labeled **time val** lists the time points for which the values of the time dependent variables are exactly defined. The time dependent variables are:

1) pyrolysis rate (kg/sec)
2) heat release rate (w)
3) heat of combustion
4) area of the fire (m^2)
5) height of the flame (m)
6) ratio of CO to CO_2
7) ratio of soot to CO_2
8) ratio of hydrogen to carbon
9) HCl production
10) HCN production
11) CT values

"Other objects" datafile: OBJECTS.DF

```
    Name: SOFA       Referenced as object #  1
    Type: 2  No. Intervals:  8
    Time:   10. Flux    0.0     Surface ignition temp:    0.
    Total Mass:   100000. GMW:   16. Volatile temp:    300.

    Time val   0.000      20.0      40.0      90.0      140.      240.      340.      740.
    Pyrol  5.500E-03 5.500E-03 5.500E-03 5.500E-03 5.500E-03 5.500E-03 5.500E-03 5.500E-03
    Qdot   1.000E+05 1.000E+05 1.000E+05 1.000E+05 1.000E+05 1.000E+05 1.000E+05 1.000E+05
    Hcomb  1.818E+07 1.818E+07 1.818E+07 1.818E+07 1.818E+07 1.818E+07 1.818E+07 1.818E+07
    Area   0.500     0.500     0.500     0.500     0.500     0.500     0.500     0.500
    High   0.250     0.250     0.250     0.250     0.250     0.250     0.250     0.250
    co/co2 2.000E-02 2.000E-02 2.000E-02 2.000E-02 2.000E-02 2.000E-02 2.000E-02 2.000E-02
  Soot/co2 0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    h/c    0.333     0.333     0.333     0.333     0.333     0.333     0.333     0.333
    HCl    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    HCN    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    c*t    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

    Name: WARDROBE   Referenced as object #  2
    Type: 2  No. Intervals:  8
    Time:   30. Flux    0.0     Surface ignition temp:    0.
    Total Mass:      37. GMW:  162. Volatile temp:    300.

    Time val   0.000      70.0      100.      140.      190.      200.      340.      1.170E+03
    Pyrol  0.000     3.140E-02 8.170E-02 0.333     1.570E-02 3.770E-02 1.570E-02 3.100E-03
    Qdot   0.000     5.000E+04 1.300E+05 5.300E+05 2.500E+04 6.000E+04 2.500E+04 5.000E+03
    Hcomb  1.590E+06 1.592E+06 1.591E+06 1.592E+06 1.592E+06 1.592E+06 1.592E+06 1.613E+06
    Area   0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    High   0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    co/co2 0.000     0.234     0.134     9.000E-03 1.600E-02 3.100E-02 6.300E-02 0.000
  Soot/co2 0.000     1.600E-02 1.900E-02 4.000E-03 0.000     0.000     0.000     0.000
    h/c    0.830     0.830     0.830     0.830     0.830     0.830     0.830     0.830
    HCl    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    HCN    0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
    c*t    1.00      1.00      1.00      1.00      1.00      1.00      1.00      1.00
```

4.2.7 Fire Specification

This section consists of three parts. The first part lists the compartment number of the compartment of fire origin, how often output is to be printed, the number of time points for which the mass loss rate is specified, the total time over which the results are printed, the fire location within the compartment of origin, the lower oxygen limit, the initial relative humidity, the fire type, and the surfaces for which the ceiling jet algorithm is turned on.

```
Compartment of origin is                    1
Print interval (seconds)                    10
Number of fire specification intervals is   2
Total time (seconds)                        200
Fire position (x,y,z)                       2.00   2.00   0.00
Lower oxygen limit (%) =                    10.0
Initial relative humidity (%) =             0.0
Fire type is a Specified (Constrained)
Ceiling jet is off for all surfaces.
```

The second part lists the initial fuel temperature, the ambient air temperature, and the ambient sea level reference pressure for the interior and exterior.

```
Pyrolysis  temperature (K) =                300.
Ambient air temperature (K) =               300.
Ambient reference pressure (Pa) =           101300.
Reference elevation (m) =                   0.
External ambient temperature (K) =          300.
External reference pressure (Pa) =          101300.
Reference elevation (m) =                   0.
```

The third part lists for each specified point of the fire the mass loss rate of the burning fuel, the heat of combustion, the rate of heat release, the height of the base of the fire with respect to the floor, and the fractional production rates of the species. Also listed is the corresponding time points.

```
Fmass=   1.40E-03   1.40E-03
Hcomb=   1.81E+07   1.81E+07
Fqdot=   2.53E+04   2.53E+04
Fhigh=   0.00       1.00E-02
C/CO2=   0.00       0.00
CO/CO2=  1.00E-02   1.00E-02
H/C=     0.33       0.33
O2=      0.00       0.00
HCN=     0.00       0.00
HCL=     0.00       0.00
Ftime=   0.00       4.00E+02
```

4.2.8 Initial Conditions

This section shows the conditions in the structure at the beginning. If this is a restart, then the conditions are those at the time step used for the restart.

```
Time =      0.0 seconds.

       Upper temp(K)     300.0     300.0
       Lower temp(K)     300.0     300.0        300.0
     Upper vol(m**3)       0.0       0.0
      Layer depth(m)       0.0       0.0
      Ceiling temp(K)    300.0     300.0
      Up wall temp(K)    300.0     300.0
     Low wall temp(K)    300.0     300.0
        Floor temp(K)    300.0     300.0
       c hcl(mg/m^2)      0.00      0.00
      uw hcl(mg/m^2)      0.00      0.00
      lw hcl(mg/m^2)      0.00      0.00
       f hcl(mg/m^2)      0.00      0.00

     Plume flow(kg/s)  1.352E+00  0.000E+00
     Pyrol rate(kg/s)  1.400E-03  0.000E+00
        Fire size(W)   0.000E+00  0.000E+00
       Plume in ul(W)  0.000E+00  0.000E+00
       Plume in ll(W)  0.000E+00  0.000E+00
        Vent fire(W)   0.000E+00  0.000E+00  0.000E+00
     On target(W/m^2)  0.000E+00  0.000E+00
        Pressure(Pa)   1.460E-02  2.191E-01
```

4.3 Results of Calculations

The final part of the output consists of the calculated results at the end of each print interval. The first line of the output is the simulation time. In this example, the results have only been listed for 200 s (see the data file above). Following the time are the temperatures of the upper and lower layers, the upper layer volume and thickness, and the temperatures of the ceiling, upper (UW.TEMP) (K) and lower walls, and the floor. The last four entries are the HCl deposition to the four surfaces: ceiling, upper wall, lower wall, and floor.

```
Time =    200.0 seconds.

       Upper temp(K)     465.6     364.2
       Lower temp(K)     314.1     302.1        300.0
     Upper vol(m**3)      12.0      20.8
      Layer depth(m)       0.8       1.3
      Ceiling temp(K)    401.5     331.2
      Up wall temp(K)    401.2     331.0
     Low wall temp(K)    400.7     330.8
        Floor temp(K)    401.4     331.1
       c hcl(mg/m^2)      0.00      0.00
      uw hcl(mg/m^2)      0.00      0.00
      lw hcl(mg/m^2)      0.00      0.00
       f hcl(mg/m^2)      0.00      0.00
```

Next is the flow of combustion products and entrained air into the upper layer from the plume, the pyrolysis rate of the fuel, the enthalpy release rate of the fire, the total convective heat transfer from the surfaces surrounding the layers to the upper and lower layers respectively, the total heat release rate from all vent fires in the compartment, the radiant heat transfer per unit area from the upper layer to an object on the floor, and the difference between the current pressure and the initial pressure at the floor.

```
Plume flow(kg/s)   2.466E-01  0.000E+00
Pyrol rate(kg/s)   1.400E-03  0.000E+00
    Fire size(W)   6.000E+04  0.000E+00
   Plume in ul(W)  0.000E+00  0.000E+00
   Plume in ll(W)  6.000E+04  0.000E+00
     Vent fire(W)  0.000E+00  0.000E+00  0.000E+00
  On target(W/m^2) 2.193E+03  5.358E+02
    Pressure(Pa)  -1.125E+00  7.114E-01
```

When PRM.DAT is run, the default graphics are displayed to the screen. The default graphics consist of four graphs. The upper left hand graph displays the upper layer temperature for each compartment. The upper right graph shows the %O_2 in the upper layer. The lower left hand graph gives the height above the floor of the interface between the upper and lower layer. The last graph in the lower right is of the heat release rate of the fire. The graph is updated according to the display interval in the input file, in this case every 5 seconds. When the CFAST run is over, the graph clears from the screen and returns to text mode. An example of the final display for PRM.DAT is:
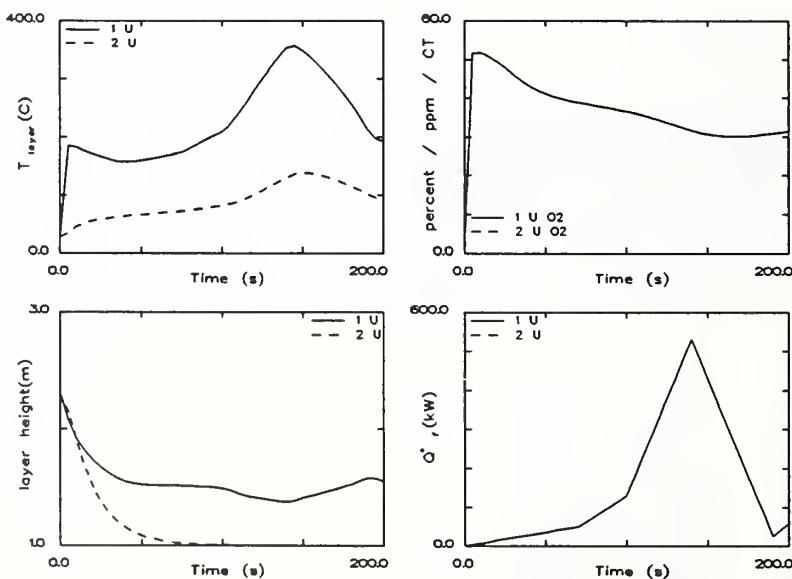
5. CPlot

The CFAST model provides 3-D pictorial results and graphs while the model is executing. The model predicts the environment produced by a fire in one of several compartments, and follows smoke and toxic gases from one compartment to another, separately predicting values for each of the variables in both the upper and lower layers. The results of these calculations are written to a special data file (the "history" file) at designated time steps. CPlot is intended to provide a visual interface to generate graphs and tables from the time histories saved by the model. CPlot has the capability to form a list of variables, read in their values at each time interval, list the values in tabular form, plot the values, and save the variables in a formatted file for use with other software. In addition, it has the capability to read history files created by other programs to plot along with CFAST data. It can read these files for several runs of each program and combine them into one or more plots and lists. To start CPlot enter the command:

```
cplot
```

See Appendix B for alternative CPlot command lines.

Once the CPlot command line has been entered, identifying information and a "command prompt" are displayed. Commands to direct the generation of the tables and graphs may now be entered. Commands available at the "command prompt" are:

> ADD, DELETE
> AGAIN
> CLEAR
> DEFAULT
> DIRECTORY
> END
> HELP
> FILE, ASCII, RAPID, TENAB
> LIST
> PLOT, REPLOT
> READ
> REVIEW
> SAVE
> SHIFT
> VARIABLE

These commands can be broken into five major groups that describe the process used to generate tabular or graphical output with CPlot. Each command has a sub-menu from which specific choices are made or actions taken. The following is a description of each of the commands. At least three characters must be used to identify a command.

5.1 Entering Data Into CPlot

The general procedure for using CPlot is to select the data from one or more files, then plot or print the data. The first step involves selecting the file. CPlot can currently read four types of data files:

- data created by the CFAST model (CFAST history files),

- data created by the TENAB model (TENAB history files)[10],

- data created in specially formatted ASCII text files from other programs including RAPID, a program developed by the Building and Fire Research Laboratory for analysis of large-scale fire tests[11], and

- ASCII text files, with data which is blank delimited.

The command for reading each of these file types is **FILE**, **TENAB**, **RAPID**, or **ASCII**, respectively. Variables for the TENAB, RAPID, and ASCII file types are specified at the same time as the command. For the CFAST history file, variables are selected with the **ADD** command. In addition to the file type and variable selection commands, several utility commands are available to provide support for data entry.

FILE   Allows the user to specify the CFAST history file name. To select particular variables from a selected history file, use the **ADD** command.

TENAB   Reads a file in the TENAB format. The TENAB program produces estimates for a number of tenability criteria for persons exposed to a fire environment predicted by the CFAST model. The user must enter the "person number" and the desired criteria to be read from the file. The possibilities are:

Tenab Variable List
1. Fractional Effective Dose Due to Gases - Bukowski
2. Fractional Effective Dose Due to Gases - Purser
3. Fractional Effective Dose Due to CO2 - Purser
4. Temperature - Deg C
5. Fractional Effective Dose Due to Convective Heat
6. CT (G-MIN/M3)
7. Flux (KW-MIN/M2)
8. Derksen Curve

RAPID   Reads a file in the RAPID format after querying for the channels to read. In order for this to work, there must be a channel which corresponds to the default channel as selected by the **DEFAULT** command. Normally this is the time channel, but it can be any other desired channel.

ASCII   Reads a file in columnar ASCII format after querying for the columns to read. In order for this to work, there must be a column which corresponds to the default column as selected by the **DEFAULT** command. Normally this is the time, but it can be any other desired column.

If a CFAST history file has been specified using the **FILE** command, variables must then be selected with the **ADD** command. The variables currently available are:

boundary surface temperature (ceiling, floor)	WALL	C
entrained mass flow in the plume	ENTRAIN	kg/s
hcl wall surface concentration	HCL	kg/m^2
heat release in lower layer	LPLUME	kW
heat release in upper layer	UPLUME	kW
heat release in flame out a vent	VFIRE	kW
heat release rate of the fire	HEAT	kW
layer height	INTE	m
layer temperature	TEMP	C
layer mass density	MASS	kg/m^3
mass flow from the plume into the upper layer	PLUME	kg/s
pyrolysis rate of the fuel	PYROL	kg/s
pressure	PRES	Pa
radiation field to a target	TARGET	W/m^2
species density	SPECIES	
total radiative heat flux into the layer	RAD	W
total convective heat flux into the layer	CONVEC	W
vent flow	VENT	kg/s
vent entrainment	JET	kg/s
volume of the upper layer	VOLUME	m^3

ADD   This command is used to build a list of CFAST variables to be read into the active list. This command applies only to files selected with the **FILE** command. **ADD** may be entered by itself or together with a list of variables that are to be added. If it is entered alone, the variables that are to be added to the list are requested. For example:

> ADD
   - INPUT VARIABLES TO BE ADDED > TEMP,PRES

                                   or

> ADD TEMP,PRES

For each variable selected, a series of questions are displayed in order to identify exactly the type of variable desired. One question displayed for all variables is:

WHICH COMPARTMENT? ->

For layer dependent variables, the user is requested to input the layer (U for upper or L for lower):

WHICH LAYER? ->

The current default value is assumed for each question when the Enter key is pressed without providing a response to the prompt. See the **DEFAULT** command to change these default values.

If the **VENTFLOW** variable is chosen, the compartments of origin and destination are requested along with the vent number. If the **SPECIES** variable is selected, the species name (O_2, CO_2,...) is requested.

The maximum number of variables allowed in the active list at any one time is 40. If the list is full or the variable is currently in the active list, the addition is disallowed, and control returns to the CPlot command prompt.

The **AGAIN, CLEAR, DELETE, READ,** and **REVIEW** commands allow the user to view and manipulate the list of variables read with the data entry commands.

AGAIN   Repeats the input of a list of variables for a new CFAST history file. CPlot maintains a list of the most recently acquired CFAST variables. As an example, select a file with the **FILE** command, and select a set of variables. Now use the **FILE** command again to select a new file. Enter the **AGAIN** command to select the original list of variables for this new file. This function simplifies direct comparisons between runs of CFAST. It works only with files selected with the **FILE** command.

CLEAR   Empties the current variable list.

DELETE   When this command is entered, the current list of CFAST variables is
                        displayed on the screen. The user is asked to select the variables to delete by
                        entering the associated number from the list. The variables must be entered
                        on a single line separated by commas or blanks. If the variable number
                        entered does not correspond to one currently on the list, it is ignored. After
                        the deletions have been completed, a new list is displayed. If the list is
                        currently empty, an appropriate error message is displayed. One caution
                        concerning order. The variables are deleted by the associated number in the
                        list, not by rank ordering within the group. This is important in conjunction
                        with use of the **AGAIN** command.

READ   Used to force a read of the data files. This is most useful for script files
                        which can be processed automatically to display data. It is equivalent to
                        pressing an enter at the "read prompt" in the interactive mode.

REVIEW   At times, the user may wish to view the current list before entering a
                        command. This may be done with the **REVIEW** command. It prints out the
                        current list along with the compartment number, species, and layer specified
                        for each of the variables.

5.2 Generating Tables and Graphs With CPlot

Once the data has been selected and read, CPlot can plot or print the data values. The
commands **LIST** and **PLOT** allow the user to generate a table of values or a graph for selected
variables. The **SHIFT** command allows the user to shift the abscissa (horizontal) or ordinate
(vertical) axis of a variable.

LIST   Lists the values of any of the variables in the current list to the screen. The
                        variables desired and the time range for the list are requested. Once the list is
                        displayed on the screen, it can be printed with the PRINT SCREEN key.

PLOT   After entering the **PLOT** command, the current list of variables is displayed.
                        To group variables together for a single graph use parentheses. Separate
                        variables within the parentheses by commas or blank spaces. Variables to be
                        plotted together on a single graph must be of the same type. As an example:

                        ```
                        Select 1->4 graphs by grouping variables
                        with parentheses followed by a return >(1 2 3 4)
                        ```

                        will plot 1 graph with 4 variables to the screen,

while:

```
Select 1->4 graphs by grouping variables
with parentheses followed by a return >1,2,3,4
```

or

```
Select 1->4 graphs by grouping variables
with parentheses followed by a return >1 2 3 4
```

plots 4 graphs of 1 variable each to the screen.

Normally, CPlot will scale the axes automatically. However, if the automatic formatting option has been turned off using the **DEFAULT** command, the user is given the opportunity to change the range of the X and Y axes along with the graph legends before the graph is drawn. The maximum and minimum values for the X and Y axes are displayed followed by a request for any changes. Press enter if no change is desired. The next axis change request is displayed:

```
The Min/Max for Temperature are:
X =      0.00 TO   2000.00
Y =      0.00 TO   1000.00

<ENTER> If no changes are desired.
     Xmin =         0.00, Change to =
     Xmax =      2000.00, Change to =
     Ymin =         0.00, Change to =
     Ymax =      1000.00, Change to =
```

Similar prompts are made for the legends for each graph. The user is allowed to change the text for each curve label and the position. If no changes are desired, the Enter key may be pressed to accept the suggested values for the legend text and position:

```
Legend for  1 (Temperature  1 U  ) is |R 1 U|. :
<ENTER> For no change:
Legend for  2 (Temperature  2 U  ) is |R 2 U|. :
<ENTER> For no change:

Legend for graph 1 is at X=     40.00, Y=    945.49
<ENTER> If no changes are desired.
     X =     40.00, Change to =
     Y =    945.49, Change to =
```

When all changes have been made, the selected graphs are plotted.

SHIFT   Used to adjust the variable axes. For example, it may be used when plotting
                            variables from different files to normalize the data to a common ignition time
                            or initial temperature. The required input is a selection of the axis to shift,
                            the amount of shift, and a list of channels. Please note that shifting the time
                            axis for a single variable will shift the time axis for all variables associated
                            with that particular file. Such an effect occurs because only one vector of
                            values is kept to represent the timeline for each file.

5.3 Saving Data With CPlot

            The **SAVE** command allows the user to create an ASCII text file in one of two formats.
These files may be used for future CPlot runs or for exporting CFAST or TENAB data to other
programs.

SAVE   Saves the values for the variables in the current list into a file. The format
                            used depends on the option chosen by the **DEFAULT** command. Columnar
                            data can be used for spreadsheet and charting programs. Row data is used to
                            make the data compatible with the data processing program (RAPID) designed
                            for the reduction of experimental data in the Building and Fire Research
                            Laboratory.

                            The user is prompted for the file name. A verification is made to determine if
                            the file currently exists. If the file does exist, the user is asked if the new
                            data should write over the old file. If the response is NO, no data is stored in
                            the file. If the response is YES or the file does not already exist, the file is
                            created, and the data stored.

                            Columnar data files are straightforward with each variable listed. The time
                            channel is the first column.

                            For files in the row format, each variable in the list is saved with the
                            following line at the beginning of each block of data:

                            I6,I6,A6,*-----------COMMENT----------

                            The first I6 represents the number of data points for that variable, the next I6
                            specifies the number given to that variable on the list, and the A6 is the actual
                            variable name. Everything after the "*" is a comment block and contains
                            information relevant to that particular variable, such as species number,
                            compartment number, layer, etc. The actual numerical data is written using
                            the format 7E11.5.

5.4 Changing the Default Parameters in CPlot

The **DEFAULT** command allows the user to change a number of default parameters within CPlot. These defaults include the format of the graphical output along with values assumed by CPlot when the user presses the Enter key without specifying input.

DEFAULT   Enables the user to set default parameters for the following:

Default compartment specifies the compartment number to be used whenever the user presses an Enter in response to a question requesting a compartment number. **Ventflow destination** specifies the compartment number for the "to compartment" for vent flows. **Default species** and **default layer** specify the species and layer, respectively, to be used whenever the user presses an Enter in response to a request for a species or a layer. **Character set** is a number from 1 to 25 which specifies a different typeface to be used. Only character sets 4, 7, 24, and 25 are supplied with CFAST. **Graphics device** specifies where the graphic output is placed. Allowable outputs are type 1 or SCREEN for output to the screen, and type 6 or HPGL for output to a file formatted for Hewlett-Packard format devices. **Automatic plot formatting** allows the user to customize the format of the graphical output. A response of Yes instructs CPlot to format the axes and legends automatically. A response of No allows the user to select the axis limits and legend text manually for each plot. **Channel for abscissa** specifies the channel number to be used for the horizontal axis for data read from RAPID format data files with the **RAPID** command. **Factor for abscissa** specifies the data column number to be used for the horizontal axis for data read in ASCII format. **Type of save file** specifies the format of the file written by the **SAVE** command. Finally, **Draw curves in color (Y/N)** and **Draw curves with dashed lines (Y/N)**, allow the user to customize the lines to be drawn for each variable in a plot.

The defaults are saved in a permanent file on the disk so the next execution of CPlot will use the defaults most recently selected.

5.5 Getting Online Help in CPlot

The **HELP** and **VARIABLE** commands provide some simple online help when using CPlot.

HELP

This command may be entered any time the user is prompted for an option. The purpose is to list to the screen the available commands with a brief explanation of each. After listing the commands, another option is requested.

VARIABLE

Shows the list of variables which are available for the files selected with the **FILE** command (CFAST history files). This list is identical to the one shown in the introduction to this CPlot section.

DIRECTORY

Shows a list of files in the current (or remote if set) directory. Functions in a manner similar to the "dir" ("ls" in Unix) command. Wildcards are used in the usual fashion.

5.6 Exiting CPlot

The **END** command terminates the execution of CPlot. If desired, any data which has been read into CPlot should be saved prior to entering this command. Any data not saved is lost upon exiting CPlot and must be re-entered if it is to be used again.

6. DESCRIPTION OF THE DATA FILE

The CFAST model requires a description of the problem to be solved. This section provides a description for the input data used by the model. In general, the order of the data is not important. The one exception to this is the first line which specifies the version number and gives the data file a title.

Most entries in the input data file can be generated using CEdit. CEdit provides online help information in addition to context-sensitive error checking. For example, CEdit will not allow the user to select a fire compartment outside the range of compartments specified on the Geometry screen. Because of these features, CEdit is the preferred method for creating and editing most CFAST input files. However, some input file key words are not supported by CEdit. For these special cases, editing of the ASCII input file using any ASCII text editor is necessary. The following sections detail the available input file key words and group them by their availability within CEdit. Subsection titles for the CEdit key words correspond to the subsection titles in the CEdit chapter of this reference. This has been done as an aid to understanding the organization of the input file.

The number of lines in a given data set will vary depending, for example, on the number of openings or the number of species tracked. A number of parameters such as heat transfer and flow coefficients have been set within CFAST as constants. Please refer to the section on source terms in the technical reference [4] to ascertain the values for these parameters.

6.1 General Format of an Input File Line

Each line of the data file begins with a key word which identifies the type of data on the line. The key words currently available are:

CEILI	specify name of ceiling descriptor(s)	(N)
CHEMI	miscellaneous parameters for kinetics	(7)
CJET	ceiling jet	(1)
CO	CO/CO_2 mass ratio	(lfmax)
CT	fraction of fuel which is toxic	(lfmax)
CVENT	opening/closing parameter	(lfmax + 3)
DEPTH	depth of compartments	(N)
DUMPR	specify a file name for saving time histories	(1)
EAMB	external ambient	(3)
FAREA	area of the base of the fire	(lfmax)
FHIGH	height of the base of the fire	(lfmax)
FLOOR	specify the name of floor property descriptor(s)	(N)
FMASS	pyrolysis rate	(lfmax)
FPOS	exact position of the fire using x, y, z coordinates	(3)
FQDOT	heat release rate	(lfmax)

FTIME	points of time on the fire timeline	(DETERMINED BY MAXIMUM LINE SIZE)
HCL	hcl/pyrolysis mass ratio	(lfmax)
HCN	hcn/pyrolysis mass ratio	(lfmax)
HCR	hydrogen/carbon mass ratio of the fuel	(lfmax)
HEIGH	interior height of a compartment	(N)
HI/F	absolute height of the floor of a compartment	(N)
HVENT	specify vent which connect compartments horizontally	(7)
INELV	specify **interior** node elevations (for ventilation ducts)	(2 x # of interior nodes)
LFBO	compartment of fire origin	(1)
LFBT	type of fire	(1)
LFMAX	**NO LONGER SUPPORTED IN THE DATA FILE**	
LFPOS	position of the fire in the compartment	(1)
MVDCT	describe a piece of (circular) duct work	(9)
MVFAN	give the pressure - flow relationship for a fan	(5 to 9)
MVOPN	Specify an opening between a compartment and ventilation system	(5)
OBJECT	additional objects to be burned	(7)
OBJFL	alternative object database file	(1)
OD	C/CO_2 mass ratio	(lfmax)
O2	ratio of oxygen to carbon in the fuel	(lfmax)
RESTR	specify a restart file	(2)
TAMB	ambient inside the structure	(3)
THRMF	alternative thermal properties file	(1)
TIMES	time step control of the output	(5)
VERSN	version number and title	(fixed format 2)
VVENT	specify a vent which connects compartments vertically	(4)
WALLS	specify the name of wall property descriptor(s)	(N)
WIDTH	width of the compartments	(N)
WIND	scaling rule for wind effects	(3)

The number in parenthesis is the maximum number of entries for that line. "N" represents the number of compartments being modeled. The outside (ambient) is designated by one more than the number of compartments, N+1. Thus, a three compartment model would refer to the outside as compartment four. An entry for LFMAX is no longer supported directly. The value for LFMAX is determined by the number of entries on the FTIME line.

Each line of input consists of a label followed by one or more alphanumeric parameters associated with that input label. The label must always begin in the first space of the line and be in capital letters. Following the label, the values may start in any column, and all values must be separated by either a comma or a space. Values may contain decimal points if needed or desired. They are not required. Units are standard SI units. Most parameters have default values which can be utilized by omitting the appropriate line. These are indicated in the discussion. The maximum line length is 128 characters, so all data for each key word must fit in this number of characters.

6.2 Key Words Available in CEdit

6.2.1 Overview

The first line in the file must be the version identification. It is a required input. The VERSN line is the line that CFAST keys on to determine whether it has a correct data file. The format is fixed, that is the data must appear in the columns specified in the text. A TIMES line is also required in order to specify the length of time over which the simulation takes place. The RESTR line is an optional line used to restart the model at a specified simulation time within an existing history file.

Example:

```
VERSN     1 Example Case for CFAST 1.6 User's Guide
TIMES     200    10    10    0    0
```

Key word: RESTR	
Input: Restart File (See Section 6.2.10), Restart Time	
Restart Time (s)	A time step is given after the name of the file and specifies at what time the restart should occur.

Key word: VERSN	
Inputs: Version Number, Title	
Version Number	The version number parameter specifies the version of CFAST for which the input data file was prepared. Normally, this would be 1. It must be in columns 8-9.
Title	The title is optional and may consist of letters, numbers, and/or symbols that start in column 11 and may be up to 50 characters. It permits the user to uniquely label each run.

Key word: TIMES	
Inputs: Simulation time, Print Interval, History Interval, Display Interval, Copy Count	
Simulation Time (s)	Simulation time is the length of time over which the simulation takes place. The maximum value for this input is 86400 s (1 day). The simulation time parameter is required.
Print Interval (s)	The print interval is the time interval between each printing of the output values. If omitted or less than or equal to zero, no printing of the output values will occur.
History Interval (s)	The history interval is the time interval between each writing of the output to the history file. The history file stores all of the output of the model at the specified interval in a format which can be efficiently retrieved for use by other programs. Section 6.2.10 provides details of the history file. A zero must be used if no history file is to be used.
Display Interval (s)	The display interval is the time interval between each graphical display of the output as specified in the graphics specification, section 6.3.2. If omitted, no graphical display will occur. There is a maximum of 200 intervals allowed. If the choice for this parameter would yield more than 200 writes, the graphs are truncated to the first 200 points.
Copy Count	Copy count is the number of copies of each graphical display to be made on the selected hard copy device as specified in the graphics specification, section 6.3.2. If omitted, a value of zero (no copies) is assumed.

6.2.2 Ambient Conditions

The ambient conditions section of the input data allows the user to specify the temperature, pressure, and station elevation of the ambient atmosphere, as well as the absolute wind pressure to which the structure is subjected. There is an ambient for the interior and for the exterior of the structure. The key word for the interior of the structure is TAMB and for the exterior of the structure is EAMB. The form is the same for both. The key word for the wind information is WIND. The wind modification is applied only to the vents which lead to the exterior. Pressure interior to a structure is calculated simply as a lapse rate based on the NOAA tables [12]. For the exterior, the nominal pressure is modified by:

$$\delta(p) = C_w \rho V^2 \quad \text{where} \quad V = V_w \left(\frac{H_i}{H_w}\right)^{P_w} \tag{1}$$

This modification is applied to the vents which lead to the exterior ambient. The pressure change calculated above is modified by the wind coefficient for each vent. This coefficient, which can vary from -1.0 to +1.0, nominally from -0.8 to +0.8, determines whether the vent is facing away from or into the wind. The pressure change is multiplied by the vent wind coefficient and added to the external ambient for each vent which is connected to the outside.

The choice for the station elevation, temperature and pressure must be consistent. Outside of that limitation, the choice is arbitrary. It is often convenient to choose the base of a structure to be at zero height and then reference the height of the structure with respect to that height. The temperature and pressure must then be measured at that position. Another possible choice would be the pressure and temperature at sea level, with the structure elevations then given with respect to mean sea level. This is also acceptable, but somewhat more tedious in specifying the construction of a structure. Either of these choices works though because consistent data for temperature and pressure are available from the Weather Service for either case.

If the EAMB or TAMB line is not included in the input file, the default values specified below are used. The WIND line is optional.

Example:

```
TAMB   300.   101300.      0.
EAMB   300.   101300.      0.
```

Key words: EAMB and TAMB Inputs: Ambient Temperature, Ambient Pressure, Station Elevation (External and Internal, respectively)	
Ambient Temperature (K)	Ambient temperature is the temperature of the ambient atmosphere. Default is 300.
Ambient Pressure (Pa)	The ambient pressure is the pressure of the ambient atmosphere. Default is 101300.
Station Elevation (m)	The station elevation is the elevation of the point at which the ambient pressure and temperature (see above) are measured. The reference point for the elevation, pressure and temperature must be consistent. This is the reference datum for calculating the density of the atmosphere as well as the temperature and pressure inside and outside of the structure as a function of height. Default is 0.

Key word: WIND Inputs: Wind Speed, Reference Height, Lapse Rate Coefficient	
Wind Speed (m/s)	Wind speed at the reference elevation. The default is 0.
Reference Height (m)	Height at which the reference wind speed is measured. The default is 10 m.
Lapse Rate Coefficient	The power law used to calculate the wind speed as a function of height. The default is 0.16.

6.2.3 Geometry

This section allows the user to portray the geometry of the structure being modeled. The size and location of every compartment in the structure MUST be described. The maximum number of compartments is 15 compartments (plus the outdoors). The structure of the data is such that the compartments are described as entities, and then connected in appropriate ways. It is thus possible to have a set of compartments which can be configured in a variety of ways. In order to specify the geometry of a structure, it is necessary to give the physical characteristics. Thus the lines labelled HI/F, WIDTH, DEPTH and HEIGH are all required. Each of these lines requires "N" data entries, that is one for each compartment.

Example:

```
WIDTH    4.00    4.00
DEPTH    4.00    4.00
HEIGH    2.30    2.30
HI/F     0.00    2.30
```

Key word: WIDTH Input: Compartment Width	
Compartment Width (m)	Compartment width specifies the width of the compartment. The number of values on the line must equal the number of compartments in the simulation.

Key word: DEPTH Input: Compartment Depth	
Compartment Depth (m)	Compartment depth specifies the depth of the compartment. The number of values on the line must equal the number of compartments in the simulation.

Key word: HEIGH Input: Compartment Height	
Compartment Height (m)	Compartment Height specifies the height of the compartment. The number of values on the line must equal the number of compartments in the simulation.

Key word: HI/F Input: Floor Height	
Floor Height (m)	The floor height is the height of the floor of each compartment with respect to station elevation specified by the TAMB parameter. The reference point must be the same for all elevations in the input data. The number of values on the line must equal the number of compartments in the simulation.

6.2.4 Vents(doors,...)

The Vents(doors,...) section of the input data file is required to specify horizontal flow connections between compartments in the structure. These may include doors between compartments or windows in the compartments (between compartments or to the outdoors). These specifications do **not** correspond to physically connecting the walls between specified compartments. Lack of an opening prevents flow. Openings to the outside are included as openings to a compartment with a number one greater than the number of compartments described in the Geometry section. The key word is HVENT. If the HVENT line is entered, the first six entries on the line are required. There is an optional seventh parameter to specify a wind coefficient. The soffit and sill specifications are with respect to the first compartment specified and is not symmetric. Reversing the order of the compartment designations does make a difference.

Horizontal flow vents may be opened or closed during the fire with the use of the CVENT key word. The initial format of CVENT is similar to HVENT specifying the connecting compartments and vent number. Each CVENT line in the input file details the open/close time dependent characteristics for one horizontal flow vent by specifying a fractional value for each LFMAX time entry. The default is 1.0 which is a fully open vent. A value of 0.5 would specify a vent which was halfway open.

Example:

```
HVENT    1   3   1     1.07     2.00     0.00     0.00
HVENT    2   3   1     1.07     2.00     1.00     0.00
CVENT    1   3   1     1.00     1.00
CVENT    2   3   1     1.00     1.00
```

Key word: CVENT	
Inputs: First Compartment, Second Compartment, Vent Number, Width	
First Compartment	The first compartment.
Second Compartment	The second compartment is the compartment number to which the first compartment is connected.
Vent Number	This number specifies which vent is being described. It can range from one to four.
Width	Fraction that the vent is open. This applies to the width only. The sill and soffit are not changed. The number of values on the line must equal the number of points on the fire timeline.

Key word: HVENT Inputs: First Compartment, Second Compartment, Vent Number, Width, Soffit, Sill, Wind	
First Compartment	The first compartment is simply the first connection.
Second Compartment	The second compartment is the compartment number to which the first compartment is connected. The order has one significance. The height of the sill and soffit are with respect to the first compartment specified.
Vent Number	There can be as many as four vents between any two compartments. This number specifies which vent is being described. It can range from one to four.
Width (m)	The width of the opening.
Soffit (m)	Position of the top of the opening above the floor of the compartment number specified as the first compartment.
Sill (m)	Sill height is the height of the bottom of the opening above the floor of the compartment number specified as the first compartment.
Wind	The wind coefficient is the cosine of the angle between the wind vector and the vent opening. This applies only to vents which connect to the outside ambient (specified with EAMB). The range of values is -1.0 to +1.0. If omitted, the value defaults to zero.

6.2.5 Vents(ceiling,...)

The Vents(ceiling,...) section of the input data file describes any vertical flow openings, such as scuddles, between compartments in the structure (or between a compartment and the outdoors). Openings to the outside are included as openings to a compartment with a number one greater than the number of compartments described in the Geometry section. Each VVENT line in the input file describes one vertical vent. There are four parameters, the connected compartments, the shape of the opening, and the effective area of the vent. At the present time, there is not an equivalent CVENT mechanism for opening or closing the vertical vents.

Example:

```
VVENT    2    1   1.00    1
```

Key word: VVENT	
Inputs: First Compartment, Second Compartment, Area, Shape	
First Compartment	The first compartment is simply the first connection.
Second Compartment	The second compartment is the compartment number to which the first compartment is connected.
Area (m^2)	This is the effective area of the opening. For a hole, it would be the actual opening. For a diffuser, the effective area is somewhat less than the geometrical size of the opening.
Shape	1 for circle or 2 for square.

6.2.6 Fans, Ducts,...

These key words are used to describe a mechanical ventilation system. The MVOPN line is used to connect a compartment to a node in the mechanical ventilation system. The elevation for each of these exterior nodes is specified as a relative height to the compartment floor on the MVOPN line. The MVDCT key word is used to specify a piece of the mechanical ventilation duct work. CAUTION: Nodes specified by each MVDCT entry must connect with other nodes, fans, or compartments. Do not specify ducts which are isolated from the rest of the system. Specify interior elevations of the mechanical ventilation nodes using the INELV line. All node elevations can be specified, but elevations for the exterior nodes, that is those connected to a compartment, are ignored. These heights are determined by entries on the MVOPN line. The heights for interior nodes are absolute heights above the reference datum specified by TAMB. The heights are specified in pairs with the node number followed by the height.

A fan is defined using the MVFAN line to indicate node numbers and to specify the fan curve with power law coefficients. There must be at least one and a maximum of five coefficients specified for each MVFAN entry. The fan coefficients are simply the coefficients of an interpolating polynomial for the flow speed as a function of the pressure across the fan housing. In this example, the coefficients:

```
B( 1) =    0.140E+00        b(1)
B( 2) =   -0.433E-03        b(2) x p
```

were calculated from entries made in CEdit:

```
              PRESSURE           FLOW

Minimum           0.00         0.1400
Maximum         300.00         0.0101
```

Example:

```
MVOPN   1   1 V    2.10    0.12
MVOPN   2   3 V    2.10    0.12
MVDCT   1   2    2.30    0.10 .00200    0.00 1.0000    0.00 1.0000
MVFAN   2   3    0.00 300.00    0.140E+00 -0.433E-03
INELV   1   2.10    2    4.40    3    4.40
```

Key word: INELV	
Inputs: Node Number, Height	
Node Number	Number of an interior node.
Height (m)	Height of the node with respect to the height of the reference datum, specified by TAMB or EAMB.

Key word: MVDCT	
Inputs: First Node Number, Second Node Number, Length, Diameter, Absolute Roughness, First Flow Coefficient, First Area, Second Flow Coefficient, Second Area	
First Node Number	First node number. This is a node in the mechanical ventilation scheme, not a compartment number (see MVOPN).
Second Node Number	Second node number.
Length (m)	Length of the duct.
Diameter (m)	All duct work is assumed to be circular. Other shapes must be approximated by changing the flow coefficient. This is done implicitly by network models of mechanical ventilation and forced flow, but must be done explicitly here.
Absolute Roughness (m)	Roughness of the duct.
First Flow Coefficient	Flow coefficient to allow for an expansion or contraction at the end of the duct which is connected to node number one. To use a straight through connection (no expansion or contraction) set to zero.
First Area (m^2)	Area of the expanded joint.
Second Flow Coefficient	Coefficient for second node.
Second Area (m^2)	Area at the second node.

Key word: MVFAN	
Inputs: First Node, Second Node, Minimum Pressure, Maximum Pressure, Coefficients	
First Node	First node in the mechanical ventilation system to which the fan is connected.
Second Node	Second node to which the fan is connected.
Minimum Pressure (Pa)	Lowest pressure of the fan curve. Below this value, the flow is assumed to be constant.
Maximum Pressure (Pa)	Highest pressure at which the fan will operate. Above this point, the flow is assumed to stop.
Coefficients	At least one, and a maximum of five coefficients, to specify the flow as a function of pressure.

Key word: MVOPN	
Inputs: Compartment Number, Duct Work Node Number, Orientation, Height, Area	
Compartment Number	Specify the compartment number.
Duct Work Node Number	Corresponding node in the mechanical ventilation system to which the compartment is to be connected.
Orientation	V for vertical or H for horizontal.
Height (m)	Height of the duct opening above the floor of the compartment.
Area (m^2)	Area of the opening into the compartment.

6.2.7 Thermal Properties

The thermophysical properties of the enclosing surfaces are described by specifying the thermal conductivity, specific heat, emissivity, density, and thickness of the enclosing surfaces for each compartment. Currently, thermal properties for materials are read from a thermal database file unique to CFAST. The data in the file simply gives a name (such as CONCRETE) which is a pointer to the properties in the thermal database. The thermophysical properties are specified at *one* condition of temperature, humidity, etc. There can be as many as three layers per boundary, but they are specified in the thermal database itself.

If the thermophysical properties of the enclosing surfaces are not included, CFAST will treat them as adiabatic (no heat transfer). If a name is used which is not in the database, CEdit will turn off the conduction calculation, and CFAST will stop with an appropriate error message.

Since most of the heat conduction is through the ceiling, and since the conduction calculation takes a significant fraction of the computation time, it is recommended that initial calculations be made using the ceiling only. Adding the walls generally has a small effect on the results, and the floor contribution is usually negligible. Clearly, there are cases where the above generalization does not hold, but it may prove to be a useful screening technique.

The default name for the thermal properties database is THERMAL.TPF. Another name can be used by selecting it during installation, or by using the key word THRMF in the CFAST data file.

Example:

```
CEILI GYPSUM     GYPSUM
WALLS PINEWOOD   PINEWOOD
FLOOR CONCRETE   CONCRETE
```

Key word: CEILI	
Inputs: Ceiling Materials	
Ceiling Materials	The label CEILI indicates that the names of thermophysical properties on this line describe the ceiling material. If this parameter is present, there must be an entry for each compartment.

Key word: WALLS	
Inputs: Wall Materials	
Wall Materials	The label WALLS indicates that the names of thermophysical properties on this line describe the wall material. If this parameter is present, there must be an entry for each compartment.

| Key word: | FLOOR |
| Inputs: | Floor Materials |

| Floor Materials | The label FLOOR indicates that the names of thermophysical properties on this line describe the floor material. If this parameter is present, there must be an entry for each compartment. |

| Key word: | THRMF |
| Input: | Thermal Database |

| Thermal Database | The name specifies a file (up to 12 characters) from which the program reads thermophysical data. If this parameter is not specified, then either the default (THERMAL.DAT) is used, or the name is read from the configuration file. |

6.2.8 Fire Specification

The fire specifications allow the user to describe the fire source in the simulation. The location and position of the fire are specified using the LFBO and FPOS lines. Chemical properties of the fuel are specified with the CHEMI key word along with miscellaneous parameters. Turn the ceiling jet calculations on by using the CJET key word. By default, the ceiling jet is not included in a CFAST simulation.

By default, the fire is placed in the center of the compartment on the floor. To place the fire in a different location, the FPOS key word may be included in the input file. If values for any of the three variables are invalid (i.e., less than zero or greater than the compartment dimension in the appropriate direction), the location for that direction defaults to the center of the appropriate direction.
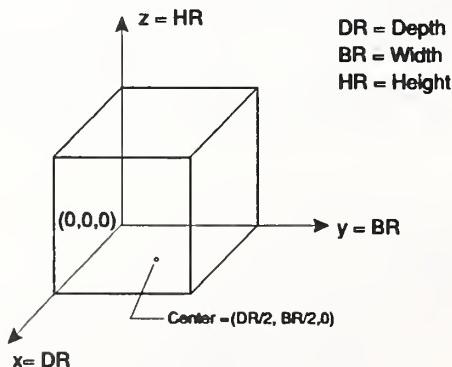
CFAST no longer supports use of the LFMAX key word in the data file. LFMAX is now determined by the number of entries on the FTIME line used to specify points of the fire timeline. The time dependent variables of the fire are described with a series of mass loss rate, rate of heat release, fuel height, and fuel area inputs. All of these specifications are optional. If entered, a total of LFMAX+1 values must be included for each time dependent input line. The defaults shown for each key word reflect the values for methane.

With the three parameters, the heat of combustion (HOC) from CHEMI, FMASS and FQDOT, the pyrolysis and heat release rate are over specified. The model uses the last two of the three to obtain the third parameter. That is, if the three were specified in the order HOC, FMASS and FQDOT, then FQDOT would be divided by FMASS to obtain the HOC for each time interval. If the order were FMASS, FQDOT and HOC, then the pyrolysis rate would be determined by dividing the heat release rate by the heat of combustion. If only two of the three are given, then those two will determine the third, and finally, if none or only one of the parameters is present, the defaults shown are used.

Species production rates are specified in a manner similar to the fire, entering the rates as a series of points with respect to time. The species which are followed by CFAST are:

- Carbon Dioxide
- Carbon Monoxide
- Concentration-Time Product
- Hydrogen Cyanide
- Hydrogen Chloride
- Nitrogen
- Oxygen
- Soot (Smoke Density)
- Total Unburned Hydrocarbons
- Water

The program performs a linear interpolation between the time points to determine the time of interest.

For a type one (LFBT=1) fire, only the concentration-time product of pyrolysate (CT) can be specified. No other species are followed. For a type two (LFBT=2) fire, nitrogen (N2), oxygen (O2), carbon dioxide (CO2), carbon monoxide (CO), hydrogen cyanide (HCN), hydrogen chloride (HCL), soot (OD), unburned fuel and water (H2O) are followed. For a type two fire, HCN, HCL, CT, O2, OD, CO and the hydrogen to carbon ratio (HCR) can be specified. In all cases, the unit of the production rates is kg/kg. However, the meaning of the production rates is different for the several types of species. See the discussion for each species key word below for the meaning of the corresponding production rate.

Example:

```
CHEMI  16.     0.  10.0     18100000.  300. 400.    0.
LFBO   1
LFBT   2
FPOS   2.00    2.00    0.00
FTIME  400.
FMASS  0.0014 0.0014
FHIGH  0.00    0.01
FAREA  0.00    0.00
FQDOT  2.53E+04 2.53E+04
CJET   OFF
HCR    0.333 0.333
CO     0.010 0.010
```

Key word:	CHEMI
Inputs:	Molar Weight, Relative Humidity, Lower Oxygen Limit, Heat of Combustion, Initial Fuel Temperature (see Section 6.3.1), Gaseous Ignition Temperature (see Section 6.3.1), Radiative Fraction (see Section 6.3.1)

Molar Weight	Molecular weight of the fuel vapor. This is the conversion factor from mass density to molecular density for "tuhc." Default is 16. It is used only for conversion to ppm, and has no effect on the model itself.
Relative Humidity (%)	The initial relative humidity in the system. This is converted to kilograms of water per cubic meter [13].
Lower Oxygen Limit (%)	The limit on the ratio of oxygen to other gases in the system below which a flame will not burn. This is applicable only to type (LFBT) 2 or later fires. The default is 10.
Heat of Combustion (J/kg)	Heat of combustion of the fuel. Default is 50000000.

Key word: CJET	
Input: OFF, CEILING, WALL, or ALL	
Current Setting	To include the calculation for the ceiling, wall, or both surfaces, the CJET key word is used together with one of the identifiers CEILING, WALL, or ALL. For example, to turn the ceiling on, use "CJET CEILING". At present, this key word effects only the calculation of the convective heating boundary condition for the conduction routines. If a particular surface is ON, the ceiling jet algorithm is used to determine the convective heating of the surface. If OFF, the bulk temperature of the upper layer determines the convective heating.

Key word: FAREA	
Inputs: Fuel Area	
Fuel Area (m)	The area of the fire at the base of the flames.

Key word: FHIGH	
Inputs: Fuel Height	
Fuel Height (m)	The height of the base of the flames above the floor of the compartment of fire origin for each point of the specified fire.

Key word: FMASS	
Inputs: Mass Loss Rate	
Mass Loss Rate (kg/s)	The rate at which fuel is pyrolyzed at times corresponding to each point of the specified fire.

Key word:	FPOS	
Inputs:	Depth, Breadth, Height (relative to the left rear corner of the compartment – see figure above)	
Depth	Position of the fire as a distance from the rear wall of the compartment (X direction).	
Breadth	Position of the fire as a distance from the left wall of the compartment (Y direction).	
Height	Height of the fire above the floor (Z direction). This value is simply added to the fire height at each time specified by the FHIGH key word.	

Key word:	FQDOT	
Inputs:	Heat Release Rate	
Heat Release Rate (W)	The heat release rate of the specified fire.	

Key word:	FTIME	
Inputs:	Time Points	
Time Points (s)	An entry indicates a point on the timeline where mass loss rate, fuel height and species are specified for the fire. This time is independent of the simulation time which is specified for the TIMES label. If the simulation time is longer than the total duration of the fire, the final values specified for the fire (mass loss rate, fuel height, fuel area, and species) are continued until the end of the simulation.	

Key word:	LFBO	
Input:	Compartment of Fire Origin	
Compartment of Fire Origin	Compartment of fire origin is the compartment number in which the fire originates. Default is 0. The outside can not be specified as a compartment. An entry of 0 turns off the main fire leaving only object fires specified by the OBJECT key word.	

Key word:	LFBT	
Input:	Fire Type	
Fire Type	This is a number indicating the type of fire. 1 Unconstrained fire 2 Constrained fire. The default is 1. See section 3.10 for a discussion of the implications of this choice.	

Key words:	HCN, HCL, CT, HCR, or O2	
Inputs:	Composition of the Pyrolyzed Fuel	
Production Rate (kg/kg)	Units are kilogram of species produced per kilogram of fuel pyrolyzed for HCN and HCL. The input for CT is the kilograms of "toxic" combustion products produced per kilogram of fuel pyrolyzed. Input for HCR is the mass ratio of hydrogen to carbon and oxygen to carbon *as it becomes available from the fuel* for O2.	

Key words:	OD and CO	
Inputs:	Yield	
Yield (kg/kg)	Input the ratio of the mass of carbon to carbon dioxide produced by the oxidation of the fuel for OD. The input for CO is the ratio of the mass of carbon monoxide to carbon dioxide produced by the oxidation of the fuel.	

6.2.9 Objects

The OBJECT key word allows the specification of additional objects to be burned in the fire scenario. The object name and object compartment are required if the OBJECT key word is used. All other input items have default values if they are not specified. These defaults are: start time 0.0, first element 1, depth (x position) one half the depth of the compartment, breadth (y position) one half the width of the compartment, and height (z position) 0.0. To specify any input item, all preceding items on the OBJECT line must also be specified. For example, the first element can not be set if start time is not set. Positioning of the object within a compartment is specified in the same manner as for the main fire. See figure below.
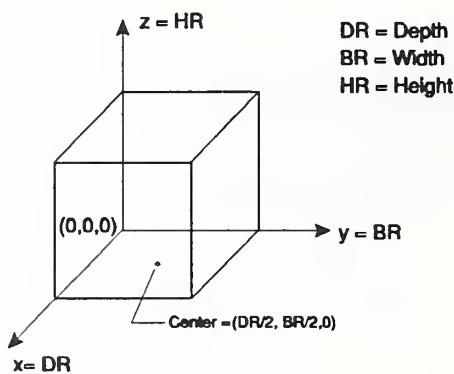
EXAMPLE:

```
OBJECT SOFA        1      10   1    4.00    2.00    0.00
OBJECT WARDROBE    1      30   3    0.00    2.00    0.00
```

Key word:	OBJFL	
Input:	Objects Database	
Objects Database	The name specifies a file (up to 17 characters) from which the program obtains object data. If this parameter is not specified, then either the default (OBJECTS.DAT) is used, or the name is read from the configuration file.	

Key word: OBJECT Inputs: Object Name, Object Compartment, Start Time, First Element, Depth, Breadth, Height	
Object Name	The name from the objects database for the desired object. Specifying a name not found in the database causes CFAST to stop with an appropriate error message. CEdit considers such an object undefined and does not display the entry.
Object Compartment	The compartment that the object is in during the simulation. If a compartment number outside the range of specified compartments is used, CFAST provides an error message and stops. CEdit considers such an object undefined and does not display the entry.
Start Time	The earliest time during the simulation when the CFAST model should check the fire scenario to determine if conditions have been met for the object to begin burning. If the flux to the object and the surface temperature are high enough, the object starts to burn.
First Element	Indicates the position on the object's surface where burning starts. This value is not currently used but needs to be set for future compatibility with the CFAST model. If a value is not known, enter a value of 1.
Depth	Position of the object as a distance from the rear wall of the object compartment (X direction).
Breadth	Position of the object as a distance from the left wall of the object compartment (Y direction)
Height	Height of the object above the floor (Z direction).

6.2.10 Files

There are several files which CFAST uses to communicate with its environment. They include 1) a configuration file, 2) the thermal database, 3) the objects database, 4) a history file, and 5) a restart file. The format of the thermal database and objects database are detailed in Appendices C and D. To access an alternate database see the appropriate input file section above.

The output of the simulation may be written to a disk file for further processing by programs such as CPlot or to restart CFAST. At each interval of time as specified by the history interval in the TIMES label, the output is written to the file specified. For efficient disk storage and optimum speed, the data is stored in an internal format and cannot be read directly with a text editor.

Example:

```
DUMPR PRM.HI
```

Key word:	DUMPR
Input:	History File
History File	The name specifies a file (up to 17 characters) to which the program outputs for plotting are written. History file is an optional input. If omitted, the file will not be generated. Note that in order to obtain a history of the variables, this parameter must be specified, and the history interval (see Section 6.2.1) must be set to a non-zero value.

Key word:	RESTR
Input:	Restart File, Restart Time (see Section 6.2.1)
Restart File	The name specifies a file (up to 17 characters) from which the program reads data to restart the model. This data must have been generated (written) previously with the history parameter discussed earlier.

6.3 Additional Key Words Unavailable in CEdit

6.3.1 Fire Specification

The LFPOS key word is provided to maintain backward compatibility with previous versions of FAST and CFAST. For exact positioning of the main fire, use the FPOS key word in section 6.2.8. The CHEMI line discussed in section 6.2.8 corresponds to chemical kinetics entry available in CEdit. At this time, CEdit does not support entry of the initial fuel temperature, gaseous ignition temperature, or the radiative fraction. These parameters must be entered on the CHEMI line using an ASCII text editor.

Example:

```
CHEMI   16.    0.  10.0    18100000.  300. 400.   0.
LFPOS   1
```

Key word:	CHEMI	
Inputs:	Molar Weight(see Section 6.2.8), Relative Humidity(see Section 6.2.8), Lower Oxygen Limit(see Section 6.2.8), Heat of Combustion(See section 6.2.8), Initial Fuel Temperature, Gaseous Ignition Temperature, Radiative Fraction	
Initial Fuel Temperature (K)	Typically, the initial fuel temperature is the same as the ambient temperature as specified in the ambient conditions section.	
Gaseous Ignition Temperature (K)	Minimum temperature for ignition of the fuel as it flows from a compartment through a vent into another compartment. If omitted, the default is arbitrarily set to the initial fuel temperature plus 100K.	
Radiative Fraction	The fraction of heat released by the fire that goes into radiation. Default is 0.15.	

Key word:	LFPOS	
Input:	Fire Position	
Fire Position	The fire position indicates where in the compartment of fire origin the fire originates and is one of the following values:	

Fire Position	The fire position indicates where in the compartment of fire origin the fire originates and is one of the following values:
	1 Center of the compartment, 2 Corner of the compartment, or 3 Along a wall of the compartment, but not near a corner of the compartment. The fire position is used to account for the entrainment rate of the plume, which depends on the location of the fire plume within the compartment. Fire positions 2 and 3 should only be used when the fire is very close to the corner or wall respectively. The default is 1.

6.3.2 Graphics Specification

A graphics specification can be added to the data file. Details of the meaning of some of the parameters is best left to the discussion of the device independent graphics software used by CFAST[14]. However, the information necessary to use it is straightforward. The general structure is similar to that used for the compartment and fire specification. One must tell the program "what to plot," "how it should appear," and "where to put it."

The key words for "where to put it" are:

DEVICE   where to plot it
BAR   bar charts
GRAPH   specify an x-y plot
TABLE   put the data into a table
PALETTE   specify the legend for CAD views
VIEW   show a perspective picture of the structure
WINDOW   the size of the window in "user" space.

The complete key word is required. That is, for the "where to put it" terms, no abbreviations are allowed. Then one must specify the variables to be plotted. They are:

VENT, HEAT, PRESSUR, WALL, TEMPERA, INTERFA,
H_2O, CO_2, CO, OD, O_2, TUHC, HCN, HCL, CT

As might be expected, these are similar key words to those used in the plotting program, CPlot. In this case, it is a reduced set. The application and use of CFAST and CPlot are different.

For each key word there are parameters to specify the location of the graph, the colors and finally, titles as appropriate. For the variables, there is a corresponding pointer to the graph of interest.

The WINDOW label specifies the user space for placement of graphs, views, etc. The most common values (which are also the default) are:

$Xl = 0., Yb = 0., Zf = 0.$
$Xr = 1279., Yt = 1023., Zb = 10.$

This is not a required parameter; however, it is often convenient to define graphs in terms of the units that are used. For example, if one wished to display a house in terms of a blueprint, the more natural units might be feet. In that case, the parameters might have the values:

$Xl = 0., Yb = 0., Zf = 0.$
$Xr = 50., Yt = 25., Zb = 30.$

Up to five graphs, tables, bar charts, and views may be displayed at one time on the graphics display. Up to five labels may be displayed at one time on the graphics display. Each type of output and each label is identified by a unique number (1-5) and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the output.

The PALETTE label performs a specialized function for showing colors on the views. A four entry table is created and used for each type of filling polygon used in a view. Up to five palettes may be defined. Each palette is identified by a unique number and placed in the window at a specified location. Xl, Yb, Zf, Xr, Yt and Zb have a meaning similar to WINDOW. However, here they specify where in the window to put the palette.

In order to see the variables, they must be assigned to one of the above displays. This is accomplished with the variable pointers as:

`(Variable) (nmopq) (Compartment) (Layer).`

Variable is one of the available variables VENT, HEAT, PRESSUR, WALL, TEMPERA, INTERFA, N_2, O_2, CO_2, CO, HCN, HCL, TUHC, H_2O, OD, CT used as a label for the line. The species listed correspond to the variable "SPECIES" in CPlot. (nmopqr) is a vector which points to:

```
index    display in

(1) n -> bar chart
(2) m -> table
(3) o -> view
(4) p -> label
(5) q -> graph
```

respectively. These numbers vary from 1 to 5 and correspond to the value of "n" in the "where to put it" specification. Compartment is the compartment number of the variable and Layer is "U" or "L" for upper and lower layer, respectively.

Example:

```
WINDOW         0      0   -100   1280   1024    1100
GRAPH 1  100.  050.  0.  600.   475.   10.   3 TIME   HEIGHT
GRAPH 2  100.  550.  0.  600.   940.   10.   3 TIME   CELSIUS
GRAPH 3  720.  050.  0.  1250.  475.   10.   3 TIME   FIRE_SIZE(kW)
GRAPH 4  720.  550.  0.  1250.  940.   10.   3 TIME   O¦D2¦O(%)
INTERFA 0 0 0 0 1    1 U
TEMPERA 0 0 0 0 2    1 U
HEAT    0 0 0 0 3    1 U
O2      0 0 0 0 4    1 U
INTERFA 0 0 0 0 1    2 U
TEMPERA 0 0 0 0 2    2 U
HEAT    0 0 0 0 3    2 U
O2      0 0 0 0 4    2 U
```

Key word:	DEVICE
Input:	Plotting Device
Plotting Device	The Plotting Device specifies the hardware device where the graphics is to be displayed. It is installation dependent. In general it specifies which device will receive the output. For most systems, 1 is for the screen from which keyboard input comes, and 6 is for the hpgl files.

Key word: WINDOW	
Inputs: Xl, Yb, Zf, Xr, Yt, Zb	
Xl	Left hand side of the window in any user desired units.
Yb	Bottom of the window in any user desired units.
Zf	Forward edge of the 3D block in any user desired units.
Xr	Right hand side of the window in any user desired units.
Yt	Top of the window in any user desired units.
Zb	Rear edge of the 3D block in any user desired units. These definitions refer to the 3D plotting block that can be seen.

Key word: BAR	
Inputs: Bar Chart Number, Xl, Yb, Zf, Xr, Yt, Zb, Abscissa Title, Ordinate Title	
Bar Chart Number	The number to identify the bar chart. Allowable values are from 1 to 5.
Xl	Left hand side of the bar chart within the window in the same units as that of the window.
Yb	Bottom of the bar chart within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the bar chart within the window in the same units as that of the window.
Yt	Top of the bar chart within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.
Abscissa Title	Title for the abscissa (horizontal axis). To have blanks in the title, use the underscore character "_".
Ordinate Title	Title for the ordinate (vertical axis). To have blanks in the title, use the underscore character "_".

Key word:	GRAPH
Inputs:	Graph Number, Xl, Yb, Zf, Xr, Yt, Zb, Color, Abscissa Title, Ordinate Title

Graph Number	The number to identify the graph. Allowable values are from 1 to 5. The graphs must be numbered consecutively, although they do not have to be given in order. It is acceptable to define graph 4 before graph 2, but if graph 4 is to be used, then graphs 1 through 3 must also be defined.
Xl	Left hand side of the graph within the window in the same units as that of the window.
Yb	Bottom of the graph within the window in the same units as that of the window.
Zf	Forward edge of the 3D (three dimensional) block within the window in the same units as that of the window.
Xr	Right hand side of the graph within the window in the same units as that of the window.
Yt	Top of the graph within the window in the same units as that of the window.
Zf	Back edge of the 3D block within the window in the same units as that of the window.
Color	The color of the graph and labels which is specified as an integer from 1 to 15. Refer to DEVICE (NBSIR 85-3235) for the colors corresponding to the color values.
Abscissa Title	Title for the abscissa (horizontal axis). To have blanks in the title, use the underscore character "_".
Ordinate Title	Title for the ordinate (vertical axis). To have blanks in the title, use the underscore character "_".

Key word: TABLE	
Inputs: Table Number, Xl, Yb, Zf, Xr, Yt, Zb	
Table Number	The table number is the number to identify the table. Allowable values are from 1 to 5. The tables must be numbered consecutively, although they do not have to be given in order. It is acceptable to define table 4 before table 2, but if table 4 is to be used, then tables 1 through 3 must also be defined.
Xl	Left hand side of the table within the window in the same units as that of the window.
Yb	Bottom of the table within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the table within the window in the same units as that of the window.
Yt	Top of the table within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.

Key word:	VIEW
Inputs:	View Number, Xl, Yb, Zf, Xr, Yt, Zb, File, Transform Matrix

View Number	View number is the number to identify the view. Allowable values are from 1 to 5. The views must be numbered consecutively, although they do not have to be given in order. It is acceptable to define view 4 before view 2, but if view 4 is to be used, then views 1 through 3 must also be defined.
Xl	Left hand side of the view within the window in the same units as that of the window.
Yb	Bottom of the view within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the view within the window in the same units as that of the window.
Yt	Top of the view within the window in the same units as that of the window.
Zf	Back edge of the 3D block within the window in the same units as that of the window.
File	File is the filename of a building descriptor file.
Transform Matrix	The Transform Matrix is a 16 number matrix which allows dynamic positioning of the view within the window. The matrix (1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1) would show the image as it would appear in a display from BUILD.

Key word:	LABEL
Inputs:	Label Number, Xl, Yb, Zf, Xr, Yt, Zb, Text, Angle1, Angle2

Label Number	Label number is the number to identify the label. Allowable values are from 1 to 5.
Xl	Left hand side of the label within the window in the same units as that of the window.
Yb	Bottom of the label within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the label within the window in the same units as that of the window.
Yt	Top of the label within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.
Text	The text to be displayed within the label. To have blanks in the title, use the underscore character "_".
Color	Color of the text to be displayed (a number from 0 to 15).
Angle1 and Angle2	Angles for display of the label in a right cylindrical coordinate space. At present, only the first angle is used and represents a positive counterclockwise rotation; set the second angle to zero. Both angles are in radians.

Key word: PALETTE Inputs: Palette Number, Xl, Yb, Zf, Xr, Yt, Zb, Color and Label	
Palette Number	Palette number is the number to identify the palette. Allowable values are from 1 to 5.
Xl	Left hand side of the palette within the window in the same units as that of the window.
Yb	Bottom of the palette within the window in the same units as that of the window.
Zf	Forward edge of the 3D block within the window in the same units as that of the window.
Xr	Right hand side of the palette within the window in the same units as that of the window.
Yt	Top of the palette within the window in the same units as that of the window.
Zb	Back edge of the 3D block within the window in the same units as that of the window.
Color and Label	There are four pairs of color/text combinations, each corresponding to an entry in the palette. The color number is an integer from 1 to 15 and the text can be up to 50 characters (total line length of 128 characters maximum). As before, spaces are indicated with an underscore character "_".

7. UTILITY PROGRAMS

There are several programs which are not really part of the simulation model but are aids in using the software. These utility programs are provided to ease the implementation and use of the model. These include:

List_obj	List the OBJECTS database
List_tpp	List the thermophysical properties database
List_clr	Test the graphics compatibility of the graphics drivers and the video display
Obj2df	Convert the prototype objects database to the direct access version used by the model (see Appendix D)
CF_set	Set the search paths, colors and other miscellaneous information for the various programs. This is the only safe way to modify HV1.CF.
Report	Provide an ASCII output of the run, based on the history file generated by the original CFAST run
ReportG	Animate the graphics display - this routine will reproduce the run time graphics as was shown by CFAST in the original. This is especially useful for those who use the version of the model which does not generate run time graphics, and those who wish to do a side by side comparison of various runs of the model.

The first five routines, List_obj, List_tpp, List_clr, Ojb2df and CF_set, are simply entered as commands. The latter two use a file and the option "/rnn." For Report, the meaning of "nn" is

    1 = > building configuration
    2 = > normal temperature/interface history
    4 = > flow field
    8 = > species
    16 = > type 1 FED results (fixed nose per compartment)
    32 = > type 2 and 3 FED results
    64 = > temperature profiles in the walls

or combinations, such as /r3 for a normal output sequence. For ReportG, the value of "nn" is a wait time between frames. With no time specified, the screen is updated as rapidly as ReportG can access the data file. With an option /r10, there is a ten second pause between each frame, and so on.

8. REFERENCES

[1]   Jones, W. W., A Multicompartment Model for the Spread of Fire, Smoke and Toxic Gases. Fire Safety Journal, 9, 55 (1985).

[2]   Jones, W. W. and Peacock, R. D., Refinement and Experimental Verification of a Model for Fire Growth and Smoke Transport, Proceedings of the 2nd International Symposium on Fire Safety Science, Tokyo (1989); Jones, W. W. and Peacock, R. D., Technical Reference Guide for FAST Version 18, National Institute Standards and Technology Technical Note 1262 (1989).

[3]   Forney, G. P. and Cooper, L. Y., The Consolidated Compartment Fire Model (CCFM) Computer Application CCFM.VENTS - Part II: Software Reference Guide, National Institute Standards and Technology Internal Report 90-4343 (1990).

[4]   Peacock, R.D., Jones, W.W., Forney, G.P., Reneke, P., Portier, R., CFAST, the Consolidated Model of Fire and Smoke Transport, National Institute of Standards and Technology, Technical Note 1299 (1992)

[5]   Jones, W. W., A Multicompartment Model for the Spread of Fire, Smoke and Toxic Gases, Fire Safety Journal 9, 55 (1985).

[6]   Jones, W. W. and Peacock, R. D., Refinement and Experimental Verification of a Model for Fire Growth and Smoke Transport, Proceedings of the 2nd International Symposium on Fire Safety Science, Tokyo (1989)

[7]   Jones, W. W. and Forney, G. P., Modeling Smoke Movement through Compartmented Structures, Natl. Inst. Stand. Technol., NISTIR 4872 (1992).

[8]   Peacock, R. D., Jones, W. W., and Bukowski, R. W., "Verification of a Model for Fire and Smoke Transport," to be published in Fire Safety J.

[9]   Bukowski, R.W., Peacock, R.D., Jones, W.W., and Forney, C.L., Software User's Guide for the HAZARD I Fire Hazard Assessment Method, Handbook 146, Volume I, National Institute of Standards and Technology, June 1991.

[10]   Bukowski, R.W., Peacock, R.D., Jones, W.W., and Forney, C.L., Technical Reference Guide for the HAZARD I Fire Hazard Assessment Method, Handbook 146, Volume II, National Institute of Standards and Technology, June 1991

[11]   Peacock, R.D., Breese, J.N., Forney, C.L., A Users Guide for RAPID, Version 2.3, National Institute of Standards and Technology Special Publication 798 (1991)

[12]   U.S. Standard Atmosphere (1976), a joint publication of the National Oceanographic and Atmospheric Administration and the National Aeronautics and Space Administration.

[13]   Haltiner, G. J. and Martin, F. L., Dynamical and Physical Meteorology, York (1957).

[14]   Jones, W.W. and Fadell, A.B., A Device Independent Graphics Kernel, NBSIR 85-3235 National Bureau of Standards (USA) (1988)

Appendix A: EXAMPLE INPUT FILES

A.1 PRM.DAT

```
VERSN    1 Example Case for CFAST 1.6 User's Guide
TIMES    200    10    10    0    0
TAMB    300.  101300.    0.
EAMB    300.  101300.    0.
HI/F     0.00    2.30
WIDTH    4.00    4.00
DEPTH    4.00    4.00
HEIGH    2.30    2.30
HVENT   1  3  1   1.07    2.00    0.00    0.00
HVENT   2  3  1   1.07    2.00    1.00    0.00
CVENT   1  3  1   1.00    1.00
CVENT   2  3  1   1.00    1.00
VVENT   2  1 1.00    1
MVOPN   1    1 V   2.10    0.12
MVOPN   2    3 V   2.10    0.12
MVDCT   1    2   2.30    0.10 .00200    0.00 1.0000    0.00 1.0000
MVFAN   2    3   0.00 300.00  0.140E+00 -0.433E-03
INELV   1   2.10    2    4.40    3    4.40
CEILI GYPSUM     GYPSUM
WALLS PINEWOOD   PINEWOOD
FLOOR CONCRETE   CONCRETE
CHEMI    16.      0.   10.0     18100000.  300. 400.    0.
LFBO    1
LFBT    2
FPOS     2.00    2.00    0.00
FTIME    400.
FMASS  0.0014 0.0014
FHIGH    0.00    0.01
FAREA    0.00    0.00
FQDOT  2.53E+04 2.53E+04
CJET OFF
HCR    0.333 0.333
CO     0.010 0.010
OBJECT SOFA        1    10   1   4.00    2.00    0.00
OBJECT WARDROBE    1    30   3   0.00    2.00    0.00
DUMPR PRM.HI
```

Use Function key f6 on the CEdit Files Screen to append:

```
WINDOW        0    0  -100  1280  1024    1100
GRAPH 1  100.  050.  0.  600.  475.  10.  3 TIME  HEIGHT
GRAPH 2  100.  550.  0.  600.  940.  10.  3 TIME  CELSIUS
GRAPH 3  720.  050.  0.  1250. 475.  10.  3 TIME  FIRE_SIZE(kW)
GRAPH 4  720.  550.  0.  1250. 940.  10.  3 TIME  O¦D2¦O(%)
INTERFA 0 0 0 0 1    1 U
TEMPERA 0 0 0 0 2    1 U
HEAT    0 0 0 0 3    1 U
O2      0 0 0 0 4    1 U
INTERFA 0 0 0 0 1    2 U
TEMPERA 0 0 0 0 2    2 U
HEAT    0 0 0 0 3    2 U
O2      0 0 0 0 4    2 U
```

A.2 School Building Fire

Aus[10] used HAZARD I to provide an alternative for a code equivalency determination. As a test, an actual case from California was examined using this process. The question involved a small school building which was found in violation of the Uniform Building Code (UBC) with respect to the required separation of alternate exits. The analysis performed examined several alternative approaches to compliance with the intent of the code, with a significant variation in cost. The two story structure is bordered by a balcony on one side limiting exit travel. The scenario included here is one of several examined by Aus. It is presented to show the application of the model to an existing structure. This example illustrates the use of CFAST for applications other than residences. Although obviously not a residential structure, the scale of the building and the fire are similar to those in residences.

```
VERSN   1           SCHOOL FIRE #1
TIMES   1000 100  20   25    0
TAMB    300.  101300.      0.
EAMB    300.  101300.      0.
HI/F    0.00    0.00    0.00    0.00    0.00    0.00
WIDTH   9.10    9.10    9.10    9.10    2.00    3.00
DEPTH   4.30    4.30    4.30    4.30   30.00    3.00
HEIGH   2.30    2.30    2.30    2.30    2.30    2.30
HVENT   1  5  1    0.91    2.00    0.00
HVENT   2  5  1    0.91    2.00    0.00
HVENT   2  7  1    0.91    2.00    1.00    0.00
HVENT   3  5  1    0.01    2.00    0.00
HVENT   4  5  1    0.01    2.00    0.00
HVENT   4  7  1    0.91    2.00    1.00    0.00
HVENT   5  6  1    0.91    2.00    0.00
HVENT   5  7  1    1.20    2.30    0.00    0.00
HVENT   5  7  2    1.20    2.30    0.00    0.00
CEILI GYPSUM      GYPSUM     GYPSUM     GYPSUM     GYPSUM     GYPSUM
WALLS GYPSUM      GYPSUM     GYPSUM     GYPSUM     GYPSUM     GYPSUM
FLOOR CONCRETE   CONCRETE   CONCRETE   CONCRETE   CONCRETE   CONCRETE
CHEMI    16.     0.    3.0    17450000.  300.
LFBO    6
LFBT    2
FTIME    60.   120.   160.   180.   210.   240.   275.   300.   350.   460.   560.   760.  1260.  2460.
FMASS  0.0000 0.0232 0.0251 0.0240 0.0328 0.0447 0.1074 0.1829 0.1753 0.1630 0.0255 0.0157 0.0147 0.0060 0.0028
FHIGH   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25   0.25
FAREA   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50   0.50
CT     1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000  1.000
HCR    0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333  0.333
CO     0.000  0.000  0.000  0.000  0.009  0.017  0.017  0.018  0.018  0.020  0.019  0.002  0.000  0.000  0.000
OD     0.000  0.016  0.016  0.016  0.013  0.011  0.017  0.027  0.030  0.036  0.007  0.000  0.000  0.000  0.000
DUMPR SCHOOL.HI
```

A.3 Mechanical Ventilation

In this example, the mechanical ventilation capabilities of CFAST are demonstrated. Four key words in the CFAST input file implement this capability for a simple fan-forced ventilation system:

- MVOPN – describe an opening between a compartment and the ventilation system,
- MVDCT – describe a piece of (circular) duct work,
- MVFAN – give the pressure - flow relationship for a fan, and
- INELV – specify **interior** node elevations.

For this example, a simple three compartment test case is used. As before, only the CFAST input data file and a sample of the output is presented.

```
VERSN   1   SSU1
TIMES    180   30   4    0    0
TAMB   288.  101300.     0.
EAMB   288.  101300.     0.
H1/F     0.00    0.00    0.00
WIDTH   10.00   10.00   10.00
DEPTH   10.00   10.00   10.00
HEIGH    5.00    5.00    5.00
HVENT   1   4   1    1.00    2.10    0.00    0.00
HVENT   2   4   1    1.00    2.10    0.00    0.00
HVENT   3   4   1    1.00    2.10    0.00    0.00
CVENT   1   4   1    1.00    1.00    1.00
CVENT   2   4   1    1.00    1.00    1.00
CVENT   3   4   1    1.00    1.00    1.00
MVDCT   1 2 5. .15 .19E-3   3.30   .01767  0. 0.
MVDCT   3 4 5. .15 .19E-3   2.94   .01767  0. 0.
MVDCT   5 6 5. .15 .19E-3   3.30   .01767  0. 0.
MVDCT   7 8 5. .15 .19E-3   2.94   .01767  0. 0.
MVFAN   2 3   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVFAN   6 7   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVOPN   1 1 H 4.5 1.
MVOPN   2 4 H 4.5 1.
MVOPN   1 5 H 4.5 1.
MVOPN   3 8 H 4.5 1.
INELV   2  4.4    3 4.4   6 4.4   7 4.4
CEIL1  OFF        WB          GLASS
WALLS  OFF        WB          GLASS
FLOOR  OFF        WB          GLASS
CHEMI    16.    50.   10.0     10000000.  300.
LFBO    1
LFBT    2
FTIME    120.   1800.
FMASS   0.0100 0.0500 0.0500
FHIGH    0.00    0.00    0.00
FAREA    0.00    0.00    0.00
FQDOT   1.00E+05 5.00E+05 5.00E+05
HCL    0.200 0.200 0.200
HCR    0.333 0.333 0.333
CO     1.000 1.000 1.000
OD     0.000 0.000 0.000
DUMPR HVAC.H1
```

A.4 Hotel Lobby Fire

In this deceptively simple example, an extremely large fire (peak heat release rate 30MW) is simulated in a large hotel lobby (32.3 x 9.4 x 4.2 m). Although clearly not residential in scale, the relative scale of the fire and the openings when compared to the room size is similar to those in residences. This would lend some confidence to the results of the predictions. As with any simulation, the user's expertise should serve as a reality check on the predicted results.

```
VERSN    1     LARGE HOTEL LOBBY
TIMES    360  20   8   10    0
TAMB   300.  101300.     0.
EAMB   300.  101310.     0.
HI/F     0.00
WIDTH   32.30
DEPTH    9.40
HEIGH    4.20
HVENT   1  2  1   7.30   1.20   0.00   0.00
HVENT   1  2  2   2.40   1.20   0.00   0.00
CVENT   1  2  1   1.00   1.00   1.00   1.00   1.00
CVENT   1  2  2   1.00   1.00   1.00   1.00   1.00
CEILI DEFAULT
WALLS DEFAULT
FLOOR DEFAULT
CHEMI    0.     0.    2.0    12300000.  288.
LFBO   1
LFBT   2
FTIME     10.    70.    80.    360.
FMASS  0.0000 2.4390 2.4390 1.1382 1.1382
FHIGH    0.35   0.35   0.35   0.35   0.35
FAREA    5.60   5.60   5.60   5.60   5.60
FQDOT    0.00      3.00E+07 3.00E+07 1.40E+07 1.40E+07
CT     1.000 1.000 1.000 1.000 1.000
HCR    0.333 0.333 0.333 0.333 0.333
CO     0.000 0.000 0.000 0.000 0.000
OD     0.050 0.049 0.038 0.019 0.000
DUMPR LOBA.HI
WINDOW       0     0  -100   1280   1024    1100
GRAPH 1  100.  050.   0.   600.  475.  10.  3 TIME  HEIGHT
GRAPH 2  100.  550.   0.   600.  940.  10.  3 TIME  CELSIUS
GRAPH 3  720.  050.   0.  1250.  475.  10.  3 TIME  FIRE_SIZE(kW)
GRAPH 4  720.  550.   0.  1250.  940.  10.  3 TIME  O¦D2¦O(%)
INTERFA 0 0 0 0 1     1 U
TEMPERA 0 0 0 0 2     1 U
HEAT    0 0 0 0 3     1 U
O2      0 0 0 0 4     1 U
```

A.5 Opening and Closing Doors and Windows

In this example, the CVENT key word in the CFAST input file is used to simulate the opening and closing of doors and windows during the course of a fire in a two-story house. Although the opening and closing times in this example are arbitrary; they could also be based upon occupant actions predicted by evacuation models or breakage of windows caused by elevated temperature or other criteria in the rooms (through multiple runs of the model).

```
VERSN   1 HOUSE FIRE WITH VENT OPENING AND CLOSING
TIMES    600  30  15  15   0
TAMB    300.  101300.     0.
EAMB    300.  101300.     0.
HI/F     0.00    0.00    0.00    0.00    2.44    2.44
WIDTH    3.35    7.82    5.49    3.35    4.16    3.81
DEPTH    7.01    2.94    1.96    1.04    4.16    3.94
HEIGH    2.44    2.44    2.44    4.88    2.44    2.44
HVENT   1  3  1    1.07    2.44    0.00
HVENT   1  7  1    1.83    1.83    0.00    0.00
HVENT   2  3  1    1.02    2.44    0.00
HVENT   3  4  1    1.02    2.44    0.00
HVENT   3  7  1    1.02    2.44    0.00    0.00
HVENT   4  5  1    1.00    4.00    2.44
HVENT   5  6  1    0.81    2.03    0.00
HVENT   6  7  1    1.00    1.00    0.50    0.00
CVENT   1  3  1    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   1  7  1    0.01    0.01    0.01    0.01    1.00    1.00    1.00    1.00    1.00
CVENT   2  3  1    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   3  4  1    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   3  7  1    0.00    0.00    0.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   4  5  1    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   5  6  1    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00    1.00
CVENT   6  7  1    0.00    0.00    0.00    0.00    0.00    0.00    1.00    1.00    1.00
CEILI GYPSUM    GYPSUM    GYPSUM    GYPSUM    GYPSUM    GYPSUM
WALLS GYPSUM    GYPSUM    GYPSUM    GYPSUM    GYPSUM    GYPSUM
FLOOR PINEWOOD  PINEWOOD  PINEWOOD  PINEWOOD  PINEWOOD  PINEWOOD
CHEMI    16.     0.    6.0     15900000.   300.
LFBO    2
LFBT    2
FTIME    30.   100.   150.   151.   200.   201.   240.   600.
FMASS  0.0000 0.0314 0.0817 0.3330 0.3330 0.3000 0.3000 0.3000 0.3000
FHIGH    0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
FAREA    0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
FQDOT  0.00     4.99E+05 1.30E+06 5.29E+06 5.29E+06 4.77E+06 4.77E+06 4.77E+06 4.77E+06
CT     1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000
HCR    0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
CO     0.034 0.030 0.040 0.034 0.034 0.034 0.034 0.034 0.034
OD     0.000 0.000 0.040 0.000 0.000 0.000 0.000 0.000 0.000
DUMPR CVENT.HI
```

A.6 Interaction of Mechanical Ventilation and HCl Deposition

An example of the interaction of mechanical ventilation with hydrogen chloride deposition (HCl) can be shown using the following data file:

```
VERSN   1 SSU1
TIMES   180  30  0   0   0
TAMB    288.  101300.     0.
HI/F    0.0   0.0  0.0
WIDTH   10.0  10.0 10.
DEPTH   10.0  10.0 10.
HEIGH   5.    5.0   5.
HVENT   1  4   1  1.0  2.1   0.0
HVENT   2  4   1  1.0  2.1   0.0
HVENT   3  4   1  1.0  2.1   0.0
CEILI   OFF WB  GLASS
FLOOR   OFF WB  GLASS
WALLS   OFF WB  GLASS
LFBT    2
CHEMI   16. 50. 10. 10000000. 300.
FMASS   0.05 0.05 0.05
FTIME   120.  1800.
HCL     .1   .1  .1
CO      .10   .10  .10
HCR     0.  0.  0.
MVDCT 1 2 5. .15 .19E-3  3.30  .01767 0. 0.
MVDCT 3 4 5. .15 .19E-3  2.94  .01767 0. 0.
MVDCT 5 6 5. .15 .19E-3  3.30  .01767 0. 0.
MVDCT 7 8 5. .15 .19E-3  2.94  .01767 0. 0.
MVFAN 2 3   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVFAN 6 7   0.0 140.   0.140 3.170E-04 -1.803E-05  1.898E-07 -8.104E-10
MVOPN 1 1 H 4.5 1.
MVOPN 2 4 H 4.5 1.
MVOPN 1 5 H 4.5 1.
MVOPN 3 8 H 4.5 1.
INELV 2  4.4   3 4.4  6 4.4  7 4.4
```

In this case, there are three compartments, each with a normal vent only to the outside. The three compartments are connected to each other by mechanical ventilation ducts. The compartment layout is shown in Figure 6, with compartment #2 on the left, compartment #1 in the center and compartment #3 on the right hand side of the figure. The fire is in the center compartment (#1) and a pair of fans blows the fire gases into the other two compartments (#2 and #3). The wall lining for the second compartment is wall board, and for the third compartment glass. The two compartments are symmetric in that all openings to the outside are the same size and the fans have the same pressure curves, so flow will be the same to both sides. The fire is small, and the pyrolyzate contains 10% hydrogen chloride, to emphasize the effect of mechanical ventilation and deposition.

Figure 7 shows the difference in the HCl concentration in the *lower* layer of the two compartments not containing the fire. With no wall adsorption, the concentrations of HCl in the two gas layers would be the same. As can be seen, the deposition onto the wall is influenced by the concentration in the environment, with the HCl concentration lower in the compartment which is lined with gypsum.
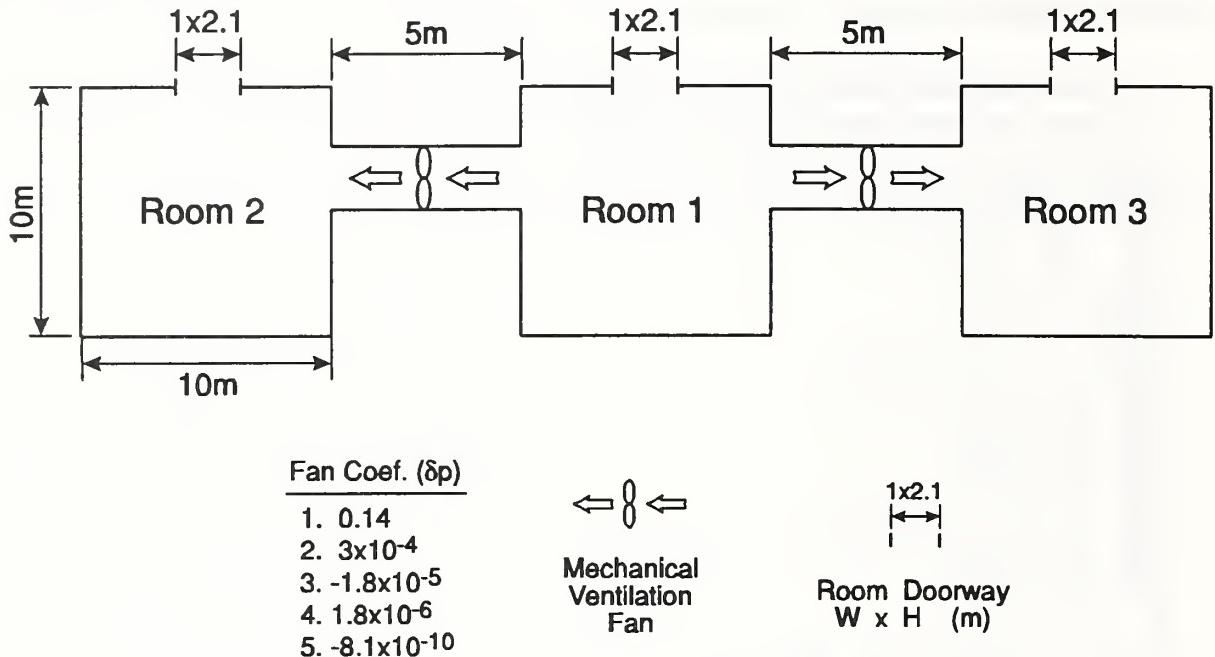
Figure 6. Plan diagram of the geometry used in the mechanical ventilation and HCl deposition calculation.

A.7 Specification of Graphical Output from CFAST

Several examples are included which illustrate the specification of graphical output for the CFAST model.

The first example is for a single compartment. This is also the 1R data file referred to in CEdit. In the latter case, the graphics descriptors are not included.

```
VERSN   1 demo #1 a single compartment
TIMES   180  0  0   5   0
TAMB    300.
HI/F    0.
WIDTH   3.3
DEPTH   4.3
HEIGH   2.3
HVENT   1    2   1   1.07  2.0  0.0
CEILI   GYPSUM
FLOOR   WOOD
LFBO    1
LFBT    2
CHEMI   0.0  0.0  1.0  18100000 300.
FMASS   .0014 .0014 .025 .045 .050 .0153 .0068 .0041
FAREA   .5   .5   .5   .5   .5   .5   .5 .5
FHIGH   .25   .25   .25   .25   .25   .25   .25 .25
FTIME   20. 40. 90. 140. 240. 340. 740.
CO      02 .02  .02  .02  .02  .02  .02  .02
CO      02 .02  .02  .02  .02  .02  .02  .02
WINDOW     0    0  -100  1280  1024   1100
```
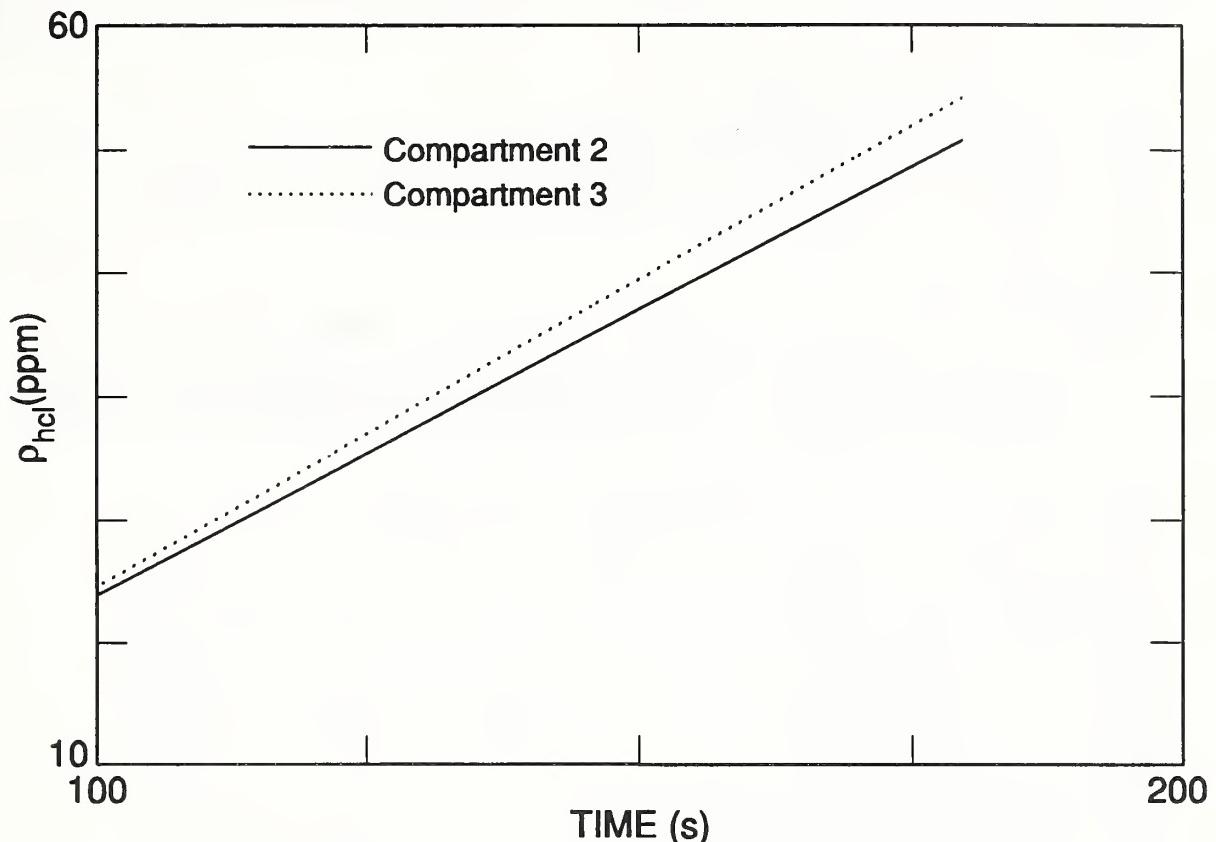
Figure 7. HCl concentration in the lower layer of compartments 2 and 3.

```
GRAPH    1  120.  300.    0.  600.  920.   10.  5 TIME  PPM
GRAPH    2  740.  300.    0. 1220.  920.   10.  5 TIME  CELSIUS
LABEL    1  970.  960.    0. 1231. 1005.   10. 15 00:00:00        0.     0.
LABEL    2  690.  960.    0.  987. 1005.   10. 13 TIME_[S]        0.     0.
LABEL    3  200.  050.    0.  520.  125.   10.  2 CO¦D2¦O_CONCENTRATION 0. 0.
CO          0 0 0 0 1   1 U
TEMPERA  0 0 0 0 2   1 U
TEMPERA  0 0 0 0 2   1 L
```

Demonstration #2 is a similar run, but showing other types of displays which are available.

```
VERSN    1 demo #2 a single compartment but plot other stuff
TIMES    180 0  0  5  0
TAMB     300.
HI/F     0.
WIDTH    3.3
DEPTH    4.3
HEIGH    2.3
HVENT    1    2   1   1.07  2.0  0.0
CEILI    KAOWOOL
FLOOR    CONCRETE
LFBO     1
LFBT     1
CHEMI    0.0  0.0  6.00  18100000 300.
```

```
FMASS    .014 .0014 .025 .045 .050 .0153 .0068 .0041
FAREA    .5    .5    .5    .5    .5    .5    .5 .5
FHIGH    .25   .25   .25   .25   .25   .25   .25 .25
FTIME    20. 40. 90. 140. 240. 340. 700.
WINDOW       0    0  -100 1280 1024  1100
GRAPH    1 150. 300.    0. 620. 920.  10.  3 TIME  PPM
LABEL    1 390. 960.    0. 651. 1005. 10. 15 00:00:00        0.    0.
LABEL    2 110. 960.    0. 407. 1005. 10. 13 TIME_[S]        0.    0.
LABEL    3 200. 050.    0. 520. 125.  10.  14 O¦D2¦O_CONCENTRATION 0. 0.
TABLE    1 700. 300.    0. 1200. 920. 10.
HEAT     0 1 0 0 0    1 U
O2       0 1 0 0 1    1 U
TEMPERA 0 1 0 0 0    1 U
TEMPERA 0 1 0 0 0    1 L
```

This data set produces two views of a building along with a table of selected quantities calculated during the simulation.

```
VERSN    1  demo #3 the original nike site evaluation
TIMES    180 0 0  5    0
TAMB     300.
HI/F     0.0  0.0  0.0  0.0  0.0  0.0
WIDTH    3.3  2.4  2.9  2.4  3.3  2.4
DEPTH    4.3 18.8  9.9  9.9  4.3  4.3
HEIGH    2.3  2.3  2.3  2.3  2.3  2.3
HVENT    1    2   1 1.07 2.0  0.0
HVENT    2    3   1 1.07 2.0  0.0
HVENT    3    7   1 0.95 .15  0.0
HVENT    2    4   1 1.07 2.0  0.0
HVENT    4    7   1  .95 .10  0.0
HVENT    2    5   1 1.07 2.0  0.0
HVENT    2    6   1 0.10 2.0  0.0
CEILI    GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM GYPSUM
LFBO     1 ROOM OF FIRE ORIGIN
LFBT     1 TYPE OF FIRE (GAS BURNER)
CHEMI    .0  0.0       1.0      18100000 300.
FMASS    .0014 .0014 .025 .045 .050 .0153 .0068 .0041
FAREA    .5   .5   .5   .5   .5   .5   .5 .5
FHIGH    .25  .25  .25  .25  .25  .25  .25 .25
FTIME    100. 200. 250. 300. 400. 500. 900.
CO       0.05 0.05 0.05 0.05 0.05 0.05 0.05 0.05
WINDOW       0    0    0 1280 1024  1100
VIEW     1 300 600 150 1200 900 200 DEMO-F3T.PIC 1 0 0 0 0 1 0 0 0 0 1 0 0 0 0 1
VIEW     2 300 300 150 1200 600 200 DEMO-F3B.PIC 1 0 0 0 0 0 -1 0 0 1 0 0 0 572 572 1
LABEL    1 820. 960.    0. 1081. 1005. 10. 14 _____        0.    0.
LABEL    2 50.  50.     0. 1080. 100.  10. 10 ¦Nike_Site_evaluation 1.57 0
LABEL    3 70.  960.    0. 367. 1005.  10. 03 FIRE_[kW]     0.    0.
LABEL    4 640. 960.    0. 937. 1005.  10. 03 TIME____      0.    0.
LABEL    5 360. 960.    0. 635. 1005.  10. 14 _____        0.    0.
TABLE    1 200. 20.     0. 950. 250.   10.
HEAT     0 0 0 5 0 1 0 1 U
TEMPE    0 1 1 0 0 1 U
INTER    0 1 1 0 0 1 U
CO       0 1 1 0 0 1 U
TEMPE    0 0 2 0 0 1 U
INTER    0 0 2 0 0 1 U
CO       0 0 2 0 0 1 U
```

Appendix B: COMMAND LINE OPTIONS

In general, the command line for starting each of the CFAST routines is:

name [option(s)] file1 file2

Options:

For the PC, an option is preceded by a "/" while on a Unix platform it is "-". There are several possible options which are used to control the CFAST programs: n, f, 1 and r. The interaction between these options and the various modules is:

	-n (/n)[3]	-f(/f)	-1(/1)	-r(/r)
CEdit	no header	context vector	error logging	na
CFAST	" "	"	"	na
CPlot	" "	"	"	na
Report	" "	na	"	what to report
ReportG	" "	na	"	time delay

n prevents display of the disclaimer notice,
f passes a configuration file - used by the shell to pass the current configuration,
1 turns on error logging,
r specification for the report generators, Report and ReportG. Refer to Section 7.

The possible file specifications on the command line for each program are:

CEdit - If a **file1** is specified, CEdit reads it as a configuration file first. If the file is not a configuration file, then CEdit will access it as a data file. If **file1** is omitted, CEdit uses the HV1.CF configuration file and the last data file by default. **file2** is not supported by CEdit.

CFAST - If **file1** is specified, CFAST reads it as a configuration file first. If the file is not a configuration file, then CFAST will access it as a data file. If **file1** is omitted, CFAST uses the HV1.CF configuration file and the last data file by default. If **file2** is specified, it is used as an output file. Otherwise, CFAST displays to the screen. If **file2**

---

[3] The first form is for Unix, and the second is for the PC

is to be specified and **file1** is not, a "," must separate **file2** from the CFAST program name.

CPlot - **file1** is an ASCII file containing the CPlot commands as they would have been entered interactively. If **file1** is omitted, CPlot uses an interactive text interface.

Report - **file1** is a history file created by CFAST when using the DUMPR key word in the CFAST data input file. Report requires entry of **file1**. On a Unix system only, the file name is case-sensitive.

ReportG - **file1** is a data file which was used to run CFAST originally. At present, **file1** is required.

Appendix C: THERMAL DATABASE

Thermal data is read from a file which is in an ASCII format. The default name is THERMAL.DAT. The distributed configuration file (HV1.CF) renames this to THERMAL.DF. An alternative can be used by changing the default with the routine CF_Set, or by using the key word THRMF in the data file that is passed to CFAST.

The relationship is by the name used in specifying the boundary. The example data file shown in Appendix A uses concrete, gypsum and pinewood. Any name can be used so long as it is in the thermal database. If a name is used which is not in the database, then CEdit will turn off the conduction calculation, and CFAST will stop with an appropriate error message. The form of an entry in the database is:

name   conductivity   specific heat   density   thickness   emissivity

and the units are:

name	1 to 8 alphanumeric characters
conductivity	Watts/meter/Kelvin
specific heat	Joules/kilogram/Kelvin
density	kilograms/cubic meter
thickness	meters
emissivity	dimensionless.

The default database that comes with CFAST (THERMAL.DF) includes:

Name	Conductivity	Specific heat	Density	Thickness	Emissivity
DFIR30	0.1800	900.0	790.0	0.0160	0.9000
PINEWOOD	0.1200	2500.0	540.0	0.0160	0.8000
CONCRETE	1.7500	1000.0	2200.0	0.1500	0.9400
REDOAK	0.1500	1300.0	640.0	0.0160	0.9000
FIBER	0.0500	1250.0	240.0	0.0160	0.9000
GYPSUM	0.1600	900.0	800.0	0.0160	0.9000
WOOD	0.0700	1000.0	250.0	0.0160	0.9800
DFIR0	0.1300	1400.0	510.0	0.0127	1.0000
DFIR10	0.1500	1500.0	560.0	0.0160	0.9000
GLASS	1.4000	760.0	2500.0	0.0160	0.9500
GLASFIBR	0.0360	720.0	32.0	0.0160	0.9000
KAOWOOL	0.2200	1047.0	128.0	0.1160	0.9700
GYP1	0.1200	900.0	800.0	0.0250	0.9000
GYP2	0.1200	900.0	800.0	0.0500	0.9000
BRICK	0.1800	900.0	790.0	0.0160	0.9000

The output listing of CFAST, and the thermal database screen for CEdit show a table of "codes." The code is an eight character string whose fields are:

1-3 number of nodes if it exceeds 'NN' which is currently 48 (36 for the PC version)
4 always blank
5 too many slabs - greater than mxslb (S)
6 inconsistent number of slabs - all properties must have the same number of slabs (I)
7 duplicate names - the first in the list is used (D)
8 used in the present calculation (U)

All of the examples shown above represent single layer partitions. The model, however, will handle up to three layers, or slabs, per partition. To specify multiple layers, each property is given one, two or three values separated by slashes. It is important that this be consistent across the whole entry, otherwise CFAST will have an ambiguous situation. The ambiguity is resolved by using the lowest number of layers.

The layers are numbered from the inside to outside. That is, the first material property represents the material on the compartment interior, and the last property is on the outside. There are several examples of this format in the THERMAL.DF file included in this distribution. One example is:

FC1_L003 .15/.03/.22 1500./1042./1047. 790./1.2/128. .016/.24/.019 .9

Since the emissivity applies only to the interior surface, it will always have only a single entry. Other values are ignored. This example represents a three layer assembly taken from Underwriters Laboratory(UL) "Fire Resistance Directory." The code stands for Floor Combustible 1 Hour, and L003 is assigned by UL.

Finally, the HCl coefficients are included for each entry in THERMAL.DF since they pertain to surface effects, and the current algorithm uses a similarity solution for the heat and mass transfer. There are seven coefficients for the HCl absorption. If the first two are zero, the others are not used even though they must be present. These coefficients have only been measured for a few materials. The most commonly used material is:

GYPSUM [0.16 900. 790. 0.016 0.90] 0.0063 191.8 0.0587 7476. 193 1.021 0.431

The numbers in brackets are shown above as the normal properties. The final seven coefficients and their units are discussed in reference [4].

Appendix D: OBJECTS DATABASE

OBJECTS.DF is the database of objects used by CFAST and CEdit. The distributed configuration file (HV1.CF) provides the default name. An alternative is available by changing the default with the routine CF_set, or for individual data files by using the key word OBJFL.

OBJECTS.DF has a special format to allow both CFAST and CEdit to access the information as quickly as possible. For that reason, a second file, OBJECTS.ORG, has been created. OBJECTS.ORG is designed so that it can be edited with any ASCII text editor. When an entry in OBJECTS.ORG is added or changed, the routine OBJ2DF should be used to convert OBJECTS.ORG to OBJECTS.DF. Failure to do this will prevent CFAST and CEdit from recognizing the changes.

The format of an object entry in OBJECTS.ORG is listed below along with the CFAST variables to which the data is assigned. Each section will first specify the format of that line for the Ith object in the data file using the CFAST variable names. The variables are then listed individually with the appropriate dimensions and units as well as a brief description. The OBJECT key word on line 1 is required in the OBJECTS.ORG file in order to generate an accurate OBJECTS.DF. Note that the default values for flux for ignition and surface temperature for ignition are infinity and the ambient respectively.

```
line 1) OBJECT OBJNAM
        OBJNAM(NUMOBJL) = Name of object (up to 8 characters)

line 2) OBJTYP OBJCRI(2,I) OBJCRI(3,I) OBJMAS OBJGMW OBJVT OBJHC
        OBJTYP(NUMOBJL) = Object type
            1 unconstrained burn
            2 constrained burn
            3 flame spread model (not yet implemented)
            4 pool fire (not yet implemented)
        OBJCRI(2,NUMOBJL) = Flux for ignition (w/m²)
        OBJCRI(3,NUMOBJL) = Surface temperature for ignition (k)
        OBJMAS(NUMOBJL)   = Total mass (kg)
        OBJGMW(NUMOBJL)   = Gram molecular weight
        OBJVT(NUMOBJL)    = Volatilization temperature (k)
        OBJHC(NUMOBJL)    = Heat of combustion (J/kg)

line 3) OBJXYZ(1,I) OBJXYZ(2,I) OBJXYZ(3,I) OBJORT(1,I) OBJORT(2,I)
OBJORT(3,I) IOPPOS PNLDS
        OBJXYZ(1,NUMOBJL) = Panel length (m)
        OBJXYZ(2,NUMOBJL) = Panel height or width (m)
        OBJXYZ(3,NUMOBJL) = Panel thickness (m)
        OBJXYZ(4,NUMOBJL) = Surface area of panel element (m²)
        OBJORT(1,NUMOBJL) = Orientation angle PHI
        OBJORT(2,NUMOBJL) = Orientation angle THETA
        OBJORT(3,NUMOBJL) = Orientation angle PSI
        IOPPOS            = Double sided panel flag (0 or 1)
        PNLDS             = Distance between sides of a panel (m)
```

```
line 4) Second panel (ignored for now)

line 5) Third panel (ignored for now)

line 6) Fourth panel (ignored for now)

line 7) OTIME(1,I) to OTIME(TOTJ,I)
        OTIME(NV,NUMOBJL) = Time history (sec)
```

Each OTIME(J,I) represents a point on the objects burn timeline where the variables below are defined exactly. CFAST will interpolate values between any two points. TOTJ is the total number of points on the specified timeline. CFAST automatically assigns an initial time zero for the objects timeline so that there will always be one fewer specified value for the timeline than for the history variables below.

The following lines are the histories for the individual parameters at each of the OTIME points.

```
line 8) OMASS(1,I) to OMASS(TOTJ+1,I)
        OMASS(NV,NUMOBJL) = Pyrols rate time history (kg/sec)

line 9) OQDOT(1,I) to OQDOT(TOTJ,I)
        OQDOT(NV,NUMOBJL) = Rate of heat release time history (w)

line10) OAREA(1,I) to OAREA(TOTJ,I)
        OAREA(NV,NUMOBJL) = Area of fire time history (m²)

line11) OHIGH(1,I) to OHIGH(TOTJ,I)
        OHIGH(NV,NUMOBJL) = Height of flame time history (m)

line12) OCO(NV,NUMOBJL) = CO/CO2 time history

line13) OOD(NV,NUMOBJL) = OD or soot time history

line14) OHCR(NV,NUMOBJL) = H/C time history

line15) OOC(1,I) to OOC(TOTJ,I)
        OOC(NV,NUMOBJL) = O/C time history

line16) OMPRODR(1,10,I) to OMPRODR(TOTJ,10,I)
        OMPRODR(NV,10,NUMOBJL) = CT time history

line17) OMPRODR(1,5,I) to OMPRODR(TOTJ,5,I)
        OMPRODR(NV,5,NUMOBJL) = HCN time history

line18) OMPRODR(1,6,I) to OMPRODR(TOTJ,6,I)
        OMPRODR(NV,6,NUMOBJL) = HCl time history
```

Appendix E: GRAPHICS DISPLAYS

Card Type	Resolution	Driver	Mode	ID
AST VGA Plus	800x600	AHDPARP	0	PP0
ATI VGA Wonder	800x600	AHDATIP	0	AP0
Everex Viewpoint VGA	800x600 1024x768	AHDEVGP	3 4	EP3 EP4
Genoa 6000 Series VGA	800x600 1024x768	AHDGVGP	1 2	VP1 VP2
Headland/Video-7 VRAM VGA	752x410 720x540 800x600 1024x768	AHDV7VP	0 1 2 3	7P0 7P1 7P2 7P3
Headland/Video-7 VGA 1024i	752x410 720x540 800x600 1024x768	AHDV7VP	0 1 2 3	7P0 7P1 7P2 7P3
IBM EGA	640x350	AHDIBME	2	IE2
IBM Personal System/2 VGA	640x480	AHDIBMV	3	IV3
Orchid Technology Designer VGA or Designer 800	800x600 1024x768	AHDVLIN	2 3	LN2 LN3
Paradise VGA Professional	800x600	AHDPARP	0	PP0
Prism Elan, Elite, or Eclipse VGA	720x540 800x600 1024x768	AHDPSMP	2 3 4	SP2 SP3 SP4
STB VGA Extra/EM	800x600 1024x768	AHDVPLN	2 3	PN2 PN3
Tecmar VGA A/D	800x440 800x600 1024x768	AHDTRIP	1 2 3	TP1 TP2 TP3
Trident TVGA 8900	800x600 1024x768	AHDTRIP	0 1	TP0 TP1
Tseng Labs ET-3000 Extended VGA	800x600 1024x768	AHDVPLN	2 3	PN2 PN3
Tseng Labs ET-4000 Extended VGA	800x600 1024x768	AHDTL4L	2 3	4L2 4L3

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

MANUSCRIPT REVIEW AND APPROVAL

INSTRUCTIONS: ATTACH ORIGINAL OF THIS FORM TO ONE (1) COPY OF MANUSCRIPT AND SEND TO:
THE SECRETARY, APPROPRIATE EDITORIAL REVIEW BOARD.

PUBLICATION DATE	NUMBER PRINTED PAGES
December 1992	106

TITLE AND SUBTITLE (CITE IN FULL)

A User's Guide for CFAST Version 1.6

CONTRACT OR GRANT NUMBER	TYPE OF REPORT AND/OR PERIOD COVERED
Internal Report	

AUTHOR(S) (LAST NAME, FIRST INITIAL, SECOND INITIAL)

Rebecca W. Portier, Paul A. Reneke, Walter W. Jones,
Richard D. Peacock

PERFORMING ORGANIZATION (CHECK (X) ONE BOX)

- [ ] NIST/GAITHERSBURG
- [ ] NIST/BOULDER
- [ ] JILA/BOULDER

LABORATORY AND DIVISION NAMES (FIRST NIST AUTHOR ONLY)

Building and Fire Research Laboratory, Fire Measurement and Research Division

SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

RECOMMENDED FOR NIST PUBLICATION

- [ ] JOURNAL OF RESEARCH (NIST JRES)
- [ ] J. PHYS. & CHEM. REF. DATA (JPCRD)
- [ ] HANDBOOK (NIST HB)
- [ ] SPECIAL PUBLICATION (NIST SP)
- [ ] TECHNICAL NOTE (NIST TN)
- [ ] MONOGRAPH (NIST MN)
- [ ] NATL. STD. REF. DATA SERIES (NIST NSRDS)
- [ ] FEDERAL INF. PROCESS. STDS. (NIST FIPS)
- [ ] LIST OF PUBLICATIONS (NIST LP)
- [X] NIST INTERAGENCY/INTERNAL REPORT (NISTIR)
- [ ] LETTER CIRCULAR
- [ ] BUILDING SCIENCE SERIES
- [ ] PRODUCT STANDARDS
- [ ] OTHER _____

RECOMMENDED FOR NON-NIST PUBLICATION (CITE FULLY) [ ] U.S. [ ] FOREIGN

PUBLISHING MEDIUM

- [ ] PAPER
- [ ] DISKETTE (SPECIFY)
- [ ] OTHER (SPECIFY)
- [ ] CD-ROM

SUPPLEMENTARY NOTES

ABSTRACT (A 1500-CHARACTER OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, CITE IT HERE. SPELL OUT ACRONYMS ON FIRST REFERENCE.) (CONTINUE ON SEPARATE PAGE, IF NECESSARY.)

CFAST is a zone model capable of predicting the environment in a multi-compartment structure subjected to a fire. This guide provides a detailed description of the pre- and post-processing routines used by the model, the data input requirements and the output produced by version 1.6 of the model.

KEY WORDS (MAXIMUM 9 KEY WORDS; 28 CHARACTERS AND SPACES EACH; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES)

compartment fires; fire growth; mathematical models; numerical models; room fires; smoke; toxicity

AVAILABILITY

- [XX] UNLIMITED
- [ ] FOR OFFICIAL DISTRIBUTION. DO NOT RELEASE TO NTIS.
- [ ] ORDER FROM SUPERINTENDENT OF DOCUMENTS, U.S. GPO, WASHINGTON, D.C. 20402
- [X] ORDER FROM NTIS, SPRINGFIELD, VA 22161

NOTE TO AUTHOR(S) IF YOU DO NOT WISH THIS MANUSCRIPT ANNOUNCED BEFORE PUBLICATION, PLEASE CHECK HERE. [ ]

ELECTRONIC FORM